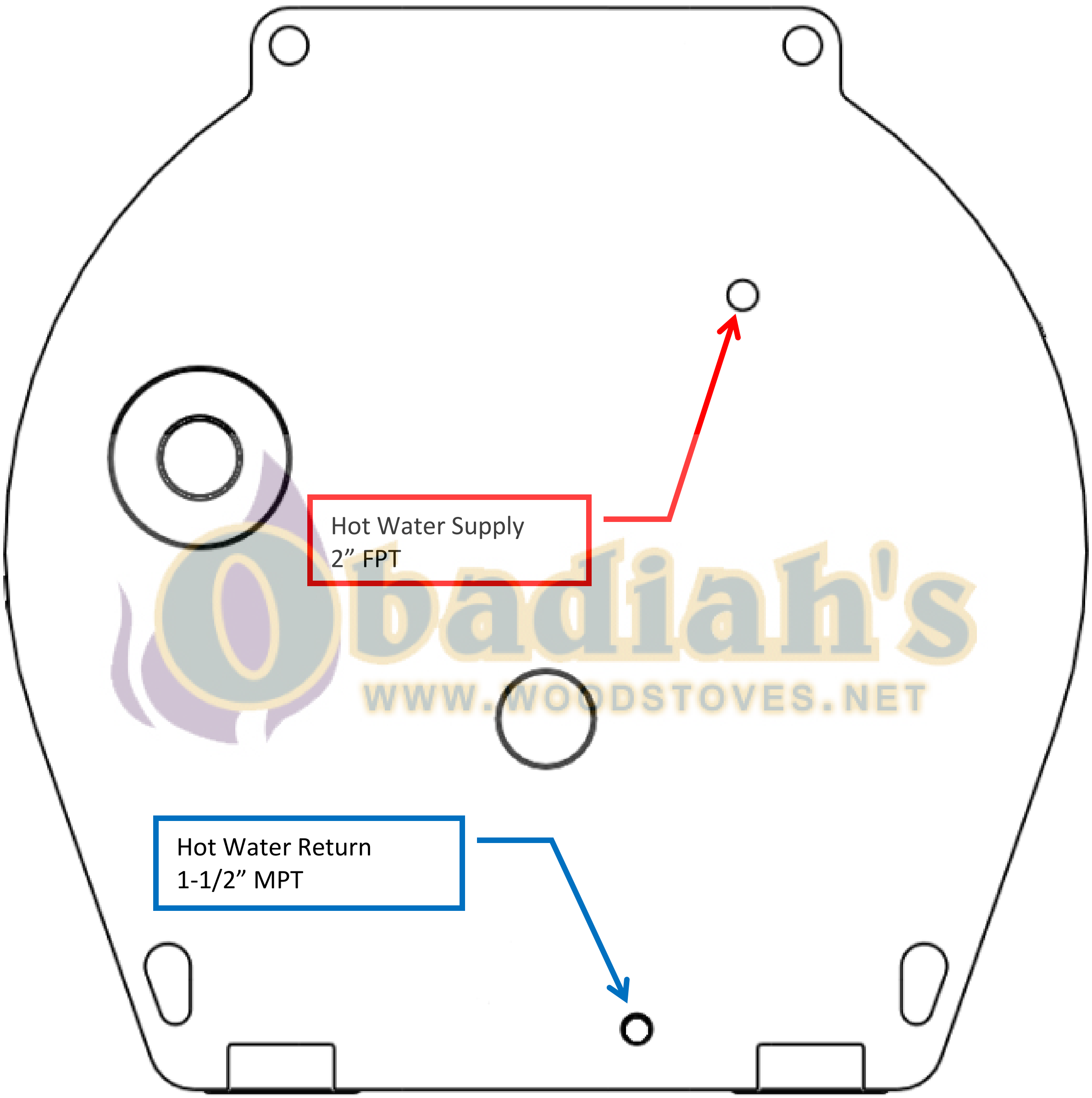
GARN®
System Design Manual



The **GARN®** unit, all related heating equipment (including pumps, piping, fan coils, hot water baseboard, radiant floor heating systems, etc) and all electrical equipment (including power wiring, controls, control wiring, back up electric heating, etc) must be installed by a qualified installer or competent **licensed** personnel in **strict compliance** with all Federal, State and local codes. All electrical equipment, devices and wiring installed with the **GARN®** unit must be **UL listed**. Installer to supply and install all code required electrical over current and disconnect devices.

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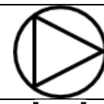
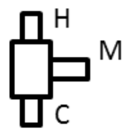
A. SYMBOLS, ABBREVIATIONS, AND SAFETY SYMBOLS:

	ABBREVIATIONS		SYMBOLS
BTUH	BTU's per hour		Pump
EWT	Entering Water Temperature		Strainer
FPS	Feet per second		Flow Arrow
FPT	Female Pipe Thread		Mixing Valve
GPM	Gallons per minute		Isolation Valve
HWS/HWR	Hot Water Supply/Hot Water Return		Flange
MBH	MBTU's (1,000 BTU) per hour		Thermometer
MMBH	MMBTU (1,000,000 BTU) per hour		Temperature Sensor
MPT	Male Pipe Thread		Check Valve
NPT	National Pipe Thread		Drain
OD	Outdoor		Connect to Existing
RWT	Return Water Temperature		

NOTICE A **notice** provides a piece of information to make a procedure easier or clearer.

⚠ CAUTION A **caution** emphasizes where equipment damage might occur. Personal injury is not likely.

⚠ WARNING A **warning** emphasizes areas where personal injury or death may occur but is not likely. Property or equipment damage is likely.

⚠ DANGER A **danger** emphasizes areas or procedures where death, serious injury, or property damage is likely if not strictly followed

B. PROMOTING CONSERVATION AND EFFICIENCY BEFORE ANYTHING ELSE:

PROBLEMS WITH IMPROPERLY COMBUSTED FUEL:

Improperly combusted wood fuel emissions are toxic to humans and animals. These emissions include: finely atomized liquid oils (creosote), very fine particulates, aromatic hydrocarbons, polycyclic organic matter, carbon dioxide, and carbon monoxide. In fact, population densities in suburban and urban locations create significant local air shed pollution issues that essentially preclude the use of coal, wood and other fuels. Complete combustion reduces these by-products significantly.

BUT! Remember this: Eliminating fuel usage is the same as burning fuel with absolutely **zero emissions**, impossible for any fuel, even natural gas! A well designed and constructed energy efficient building can reduce heating demand and fuel usage by at least half or more when compared to a "code built house."

By following the simple suggestions below, you will reduce fuel usage and annual fuel bills, create a comfortable and healthy environment for the occupants, contribute to a healthier local air shed, and realize a reasonably quick return on investment.

- Install good insulation and caulking.
- Install double glazed, argon filled energy efficient windows (or better).
- Install insulated thermally efficient doors and storm doors, with good quality weather stripping.
- Install an air-to-air heat exchanger (heat recovery ventilator) to provide ventilation.
- Insulate and caulk all rims joists.
- Insulate basements walls from floor to ceiling with methods that prevent the formation of mold and mildew.
- Utilize passive solar techniques whenever possible.
- Install water saving toilets, showers and faucets throughout.
- If you have access to natural gas, use a high efficiency natural gas condensing furnace or boiler to provide space and domestic water heating. Don't burn wood unless you want to.
- Install only high SEER air conditioning equipment with variable speed fans to effectively control indoor relative humidity.

HEATING A SWIMMING POOL:

This is best accomplished with solar heating and an evaporation prevention blanket. Solar heating has proven cost effective, dependable and efficient for many years in many countries. Solar heating is efficient in almost every area of the US. Most people do not realize that a swimming pool requires a heater that may be several times the size and capacity of their residential space heater. However, during the spring, summer and fall the amount of energy required to heat a pool is easily provided by solar panels.

For more information on solar pool heating products visit:

http://www.heliocol.com/

http://www.aetsolar.com/

http://www.h2otsun.com/

C. RULES OF THUMB FOR AN <u>INITIAL</u> ESTIMATE OF EQUIPMENT SIZE

The following are **approximate values** that may be used to estimate the size of the primary wood heating equipment. Once a project is given the "go ahead" an exact heat loss should be calculated according to *ASHRAE Fundamentals* or *Manual J* methods to ensure correct sizing. Over-sizing equipment leads to excessive first cost, inefficient operation, and increased emissions.

There are software packages that calculate an accurate heat loss value based on the detailed construction of the building. An example is Elite Software's RHVAC program. DECTRA CORPORATION can run an in-depth heat loss analysis for a fee.

To learn more about Elite Software RHVAC or to purchase a software license visit:
http://www.elitesoft.com/

COMMERCIAL HEAT LOSS:

Calculating the heat loss for commercial buildings can be more complicated than for residential structures because the building type and application vary significantly. The easiest way to get a handle on heat loss figures for a commercial facility is to use a computer software package. A good commercial heat loss packages is Elitie Software's CHVAC program.

To learn more about Elite Software CHVAC or to purchase a software license visit:
http://www.elitesoft.com/

RESIDENTIAL HEAT LOSS EXCLUDING VENTILATION:

	Old/Poorly Insulated House Uninsulated basement	Newer House Insulated Basement	Energy Efficient House Insulated Basement
Above Grade Floor Area (BTUH/sq. ft.)	25 to 35	13 to 24	8 to 15
Below Grade Floor Area (BTUH/sq. ft.)	18 to 30	10 to 20	8 to 12

RESIDENTIAL VENTILATION:

- In newer, tighter energy efficient houses, mechanical ventilation is required at a generally accepted rate of 15 cfm per person. The following should be added to the heat loss for newer houses, but not added to the heat loss of older houses (unless the older house has been reinsulated and tightly sealed against air leakage).

Heat Recovery Ventilator **Not Used**	Heat Recovery Ventilator **Used**
6,000 BTUH/person	3,000 BTUH/person

For more information on HRV products visit:
http://www.vanee-ventilation.com/
http://residential.fantech.net/

RESIDENTIAL DOMESTIC WATER HEATING:

- Maximum delivered water temperature must be 120°F or less. An anti-scald valve is required by most codes on the discharge of the water heater. Maintain the water heater at 140°F or higher to kill bacteria and virus.

Normal Family of 4, Modest Size House	Larger Family in Larger House
40,000 BTUH recovery rate	75,000 BTUH recovery rate
50 to 75 gallon water heater	100 to 120 gallon water heater

HOT TUB HEATING:

- Small (7' to 10' square x 4' deep) insulated outdoor hot tubes with an insulated cover generally require only 2,000 to 2,500 BTUH to maintain temperature when the tub is covered at outdoor temperatures of –20°F. It is assumed that the hot tub is used for brief periods (say 1 to 2 hours per day) during which time the evaporative cooling of the water's surface is the primary heat loss and may equal 6,000 to 9,000 BTUH. Any heat exchanger used to heat a hot tub should be sized for this larger value.

RADIANT FLOOR HEATING:

- Normal temperature drop is 10°F to 20°F per tube length.
- Try not to exceed a floor surface temperature of 85°F (comfort and finish materials limitations).
- **Always insulate** beneath a radiant floor system whether on or above grade. 2" of blue, pink, green or yellow board (not white bead board or polyurethane) is strongly recommend for slab on grade concrete slabs and R13 is the minimum recommended for upper level wood floors.

	Maximum Flow	Maximum Length of Individual Tube Run	Typical Maximum Number of Tubes per Manifold
1/2" PEX Tubing	0.575 gpm	300 ft	8
5/8" PEX Tubing	1 gpm	450 ft	12

GARN® recommends the use of oxygen-barried, PEX-a tubing. For more information visit:
www.mrpexsystems.com
www.uponor-usa.com
www.comfortprosystems.com

NOTICE **OXYGEN-BARRIED PEX-A TUBING IS NECESSARY IN ORDER TO MINIMIZE THE POTENTIAL FOR CORROSION.**

FORCED AIR HEATING:

⚠WARNING **DO NOT MOUNT A HOT WATER COIL ON THE RETURN SIDE OF THE FURNACE.** Warm air will be flowing over the blower motor and may not provide sufficient motor cooling. Doing so will void the furnace warrantee and the UL listing of the furnace.

⚠WARNING **DO NOT MOUNT A HOT WATER COIL IN SYSTEMS SERVED BY A HIGH EFFICIENCY CONDENSING FURNACE.** Doing so will void the furnace warrantee and the UL listing of the furnace and create the potential for flue damage and a building fire.

- Size a coil that increases the air-side pressure drop by only 0.25” to 0.33” WC. Increase blower RPM to offset this increased static pressure and maintain CFM. Select a coil that will provide a supply air temperature of 110°F or slightly greater. Code limit is 140°F.
- Pipe all coils in a **counter flow** pattern. The “normal” range of water temperature drop through a coil is 8°F to 20°F.
- Mount hot water coils (flat and A-type) on the discharge side of the furnace. In almost all cases the coil will be physically larger than the existing supply air plenum. The plenum size will have to be increased. Sheet metal work must be designed and fabricated in accordance with SMACNA guidelines.
- If the furnace is more than 12 years old, consider installing a new **unitized fan coil unit** that provides a motorized fan, filter, hot water heating coil, DX cooling coil and controls all within one insulated sheet metal unit. Such units are manufactured to replace an existing residential furnace and reasonably match the existing furnace’s overall dimensions. When selecting a unit, make sure to apply a correction factor (if necessary) for the hot water coil output at the entering water temperature (EWT) expected in the new system versus the EWT at the manufacturer’s rated output (see water temperature table in the Hot Water Baseboard Heating section of this manual).

For more information on unitized fan coil units visit:
http://www.firstco.com/
http://www.magicaire.com

HOT WATER BASEBOARD HEATING:

- HWBB output ratings are based on 1 gpm to 4 gpm flow rate and an EWT of 215°F for most ¾" and 1" standard sizes. The following correction factors are to be applied to the 215°F ratings when a lower EWT is used:

Water Temperature Correction Factors (entering air temperature = 65°F)

Supply Water Temperature (°F)	100	110	120	130	140	150	160	170	180	190	200	210	215
Correction Factor	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.69	0.78	0.86	0.95	1.00

EXAMPLE:

The above table can also be used with baseboard rated at an EWT different 215°F. For example, if an EWT of 140°F is to be used, and the baseboard manufactured rated its baseboard at a an EWT of 180°F, then the appropriate correction factor is:

$$\boldsymbol{Correction\ Factor_{@140°F} = \frac{Correction\ Factor(215°F\ rating\ table)_{@140°F}}{Correction\ Factor(215°F\ rating\ table)_{@180°F}} = \frac{0.38}{0.69} = 0.55}$$

- Normal temperature drop is 10°F to 20°F per HWBB run. GARN® equipment and many **non-wood** systems today are based on an EWT of 140°F and a RWT of 120°F to take advantage of condensing boilers.
- Combining a radiant floor manifold and PEX tubing with HWBB, can yield individual room control with a wall mounted, night set back thermostats.
- Modern European flat panel wall mounted steel radiators are similar in flow requirements as HWBB.

For more information on HWBB products visit:
www.sterlingheat.com

GLYCOL CORRECTION FACTORS AND FREEZE PROTECTION TABLES:

PROPYLENE GLYCOL FREEZE AND BURST PROTECTION

Temp (°F)	Freeze Protection (% by volume)	Burst Protection (% by volume)
20	18%	12%
10	29%	20%
0	36%	24%
-10	42%	28%
-20	46%	30%
-30	50%	33%
-40	54%	35%
-50	57%	35%
-60	60%	35%

PROPYLENE GLYCOL HEAT AND FLOW CORRECTION

% By Volume	Heat Transfer	Pump Flow
20%	0.987	1.013
25%	0.978	1.022
30%	0.969	1.032
35%	0.957	1.045
40%	0.944	1.059
45%	0.928	1.077
50%	0.912	1.096
55%	0.893	1.120
60%	0.873	1.145

PROPYLENE GLYCOL PRESSURE DROP CORRECTION

% By Volume	140°F Solution	100°F Solution
20%	1.067	1.098
25%	1.078	1.120
30%	1.089	1.141
35%	1.106	1.168
40%	1.122	1.196
45%	1.139	1.228
50%	1.156	1.261
55%	1.172	1.293
60%	1.189	1.326

NOTES:

1. GARN® recommends the use of Propylene glycol because it is not as toxic as Ethylene glycol. Check with the chemical manufacturer for specific concentration requirements.
2. The "Heat Transfer" correction factors represent the decrease in heat transfer when compared with 100% water and no change in flow rate. The "Pump Flow" correction factors represent the increase in flow required to maintain the same heat output rate as 100% water.
3. The "Pressure Drop" correction factors represent the increase in pressure drop of the system due to the glycol solution as compared to water at the same temperature.

EXAMPLE:

Select a propylene glycol solution for freeze protection of a coil designed for use as an outdoor air heating coil in Portland, ME. The ASHRAE design heating dry bulb temperature in Portland, ME is -1°F. By using the above table, a glycol solution of 36% is required for freeze protection.

EXAMPLE:

Let's say, the outdoor air coil in the previous example is rated for 50,000 BTUH at 140°F EWT, 20° ΔT, 5 GPM. What is the coil's rated output with a 36% propylene glycol solution? What increase in GPM is required to maintain the 50,000 BTUH heat output rate? What increase in pressure drop will the pump see?

$$\boldsymbol{Adjusted\ Heat\ Output = 0.957 * 50{,}000 = 47{,}850\ [btuh]}$$

$$\boldsymbol{Adjusted\ GPM = 5\ [gpm] * 1.045 = 5.2\ [gpm]}$$

$$\boldsymbol{Pressure\ Drop\ Increase\ Factor = 1.106}$$

THE DIFFERENCE BETWEEN FREEZE AND BURST PROTECTION: (DOW CHEMICAL[1])

Burst protection is required if your heating system/fluid will sit dormant at temperatures below freezing without being pumped, putting the pipes in danger of bursting. For these situations a slushy mixture is acceptable, because the fluid will not be pumped through the system. A slushy mixture is one that contains water and glycol, but as mixture of liquid and frozen ice crystals. Trying to pump fluid containing ice crystals can result in damage to system components. Since the mixture expands as it freezes, there must be enough volume available in the system to accommodate the expansion.

Freeze protection is required if your heating system/fluid is going to be pumped at temperatures at or below the freezing point of the fluid. For example, systems that are dormant for much of the winter, but require start up during the cold weather, or systems that would be at risk if the power or pump failed. For these situations, the system must have enough glycol present to prevent any ice crystals from forming. It generally requires more glycol for freeze protection, keeping the fluid completely liquid, than it does for burst protection, where a slushy mixture is acceptable.

PUMP LAWS AND FAN LAWS:

Depending on the application, a pump or fan may need to be sped up or slowed down to achieve the desired function in a heating system. Use the following handy equations to calculate the increase or decrease in flowrate, pressure, and power consumption based on the original and the new pump or fan speed (RPM).

PUMPS

$$GPM_2 = GPM_2\left(\frac{RPM_2}{RPM_1}\right)$$

$$Head_2 = Head_1\left(\frac{RPM_{new}}{RPM_{old}}\right)^2$$

$$Power_2 = Power_1\left(\frac{RPM_{new}}{RPM_{old}}\right)^3$$

FANS

$$CFM_2 = CFM_1\left(\frac{RPM_2}{RPM_1}\right)$$

$$Pressure_2 = Pressure_1\left(\frac{RPM_{new}}{RPM_{old}}\right)^2$$

$$Power_2 = Power_1\left(\frac{RPM_{new}}{RPM_{old}}\right)^3$$

[1] https://dow-answer.custhelp.com/app/answers/detail/a_id/5206/~/lttf---burst-protection-vs-freeze-protection-for-glycol-based-heat-transfer

D. PIPING AND PUMP SIZING

Correctly sized piping and pumps are necessary for the efficient and safe transport of heated water from the GARN® WHS unit to the building heating system.

NOTICE All piping, pumps, wiring and controls, etc must be sized and installed by a qualified and licensed professional. All items are to be installed in full compliance with all national, state and local codes. For installations not covered in this manual contact your local GARN® dealer for design assistance.

PIPING DESIGN AND CALULCATION GUIDELINES

Size all above grade and underground piping per standard industry guidelines:

- Maximum head loss of 4' to 6' per 100' of pipe for energy conservation.
- Maximum velocity of 8' per second to minimize surface erosion potential in most pipes.
- Maximum velocity of 6' per second to limit noise.

Incorrect pipe sizing will adversely affect the heating system performance, efficiency and cost of operation. Undersized piping may cost less to install, but the pump size must be increased, adding significantly to the pump cost and the cost of operation. Head loss data for a specific pipe or tubing, and for various fittings is tabulated in manufacturer literature, plumbing manuals, state plumbing codes and local building codes. A representative sample of the head loss associated with various fittings for copper or steel is listed below. Recommended flow rates for various pipe materials are tabulated on the next two pages.

EQUIVALENT FEET OF PIPE FOR SCREWED FITTINGS AND VALVES

(for steel and copper)

NOMINAL PIPE SIZE, INCHES	1/2	3/4	1	1 1/4	1 1/2	2
45 Degree Elbow, Regular	0.8	0.9	1.3	1.7	2.1	2.7
90 Degree Elbow, Long	2.2	2.3	2.7	3.2	3.4	3.6
90 Degree Elbow, Regular	3.6	4.4	5.2	6.6	7.4	8.5
Gate Valve, Open	0.7	0.9	1.0	1.5	1.8	2.3
Ball valve, Full Port, Open	0.3	0.4	0.5	0.7	0.8	1.0
Globe Valve, Open	22.0	24.0	29.0	37.0	42.0	54.0
Tee-Branch Flow	4.2	5.3	6.6	8.7	9.9	12.0
Tee-Line Flow	1.7	2.4	3.2	4.6	5.6	7.7
Strainer	5.0	6.6	7.7	18.0	20.0	27.0
Swing Check Valve	8.0	8.8	11.0	13.0	15.0	19.0

EQUIVALENT FEET OF PIPE FOR PEX FITTINGS

(brass fittings)

Nominal pipe size, inches	1/2	3/4	1	1 1/4	1 1/2	2
90 Degree Elbow	3.0	2.2	3.4	9.6	10.9	11.3
Coupling	1.0	0.3	0.2	1.5	2.7	1.4
Tee-Branch Flow	2.0	0.8	2.0	8.8	11.6	12.1
Tee-Line Flow	1.0	0.3	0.2	1.6	2.1	1.6

(EP fittings)

Nominal pipe size, inches	1/2	3/4	1	1 1/4	1 1/2	2
90 Degree Elbow	3.7	2.3	4.6	10.0	11.5	-
Coupling	1.0	0.2	0.2	-	-	-
Tee-Branch Flow	1.0	0.2	0.2	3.8	1.8	-
Tee-Line Flow	2.3	0.8	2.0	8.6	10.6	

FLOW AND HEAT CAPACITY @ 4' OF HEAD LOSS PER 100' OF PIPE LENGTH

SIZE	INSIDE DIA.	FLOW, gpm	BTU/HR 10°F ΔT	BTU/HR 20°F ΔT	BTU/HR 30°F ΔT
Oxygen Barriered PEX Tubing					
5/8"	0.574"	2.5	12,500	25,000	37,500
3/4"	0.678"	3	15,000	30,000	45,000
1"	0.875"	5.5	27,500	55,000	82,500
1 1/4"	1.280"	15	75,000	150,000	225,000
1 1/2"	1.600"	27	135,000	270,000	405,000
2"	2.030"	52	260,000	520,000	780,000
Type L Rigid Copper Tube - max. vel = 6'/sec for noise; max. vel = 10'/sec for erosion					
3/4"	0.785"	3.5	17,500	35,000	52,000
1"	1.025"	6.5	32,500	65,000	97,000
1 1/4"	1.265"	12	60,000	120,000	180,000
1 1/2"	1.505"	18	90,000	180,000	270,000
2"	1.985"	39	195,000	390,000	585,000
Schedule 40 Black Steel Pipe					
3/4"	0.824"	4.2	21,000	42,000	63,000
1"	1.049"	8	40,000	80,000	120,000
1 1/4"	1.380"	17	85,000	170,000	255,000
1 1/2"	1.610"	25	125,000	250,000	375,000
2"	2.067"	48	240,000	480,000	720,000

FLOW AND HEAT CAPACITY @ 6' OF HEAD LOSS PER 100' OF PIPE LENGTH

SIZE	INSIDE DIA.	FLOW, gpm	BTU/HR 20°F ΔT	BTU/HR 30°F ΔT
Oxygen Barriered PEX Tubing				
5/8”	0.574”	3	30,000	45,000
3/4"	0.678"	4.5	45,000	67,500
1"	0.875”	6.5	65,000	97,500
1 1/4"	1.280"	19	190,000	285,000
1 1/2"	1.600"	34	340,000	510,000
2"	2.030"	64	640,000	960,000
Type L Rigid Copper Tube - max. vel = 6'/sec for noise; max. vel = 10'/sec for erosion				
3/4"	0.785"	4.2	42,000	63,000
1"	1.025"	8.5	85,000	127,000
1 1/4"	1.265"	15	120,000	180,000
1 1/2"	1.505"	23	230,000	345,000
2"	1.985"	48	480,000	720,000
Schedule 40 Black Steel Pipe				
3/4"	0.824"	5.5	55,000	82,000
1"	1.049"	9.5	95,000	142,000
1 1/4"	1.380"	19	190,000	285,000
1 1/2"	1.610"	30	300,000	450,000
2"	2.067"	60	600,000	900,000

NOTE: **Head loss for different GPMs than those listed in the flow and heat capacity tables can be ESTIMATED with the following formula:**

$$\Delta P = \left(\frac{\dot{V}}{\dot{V}_{Table}}\right)^2 \Delta P_{Table}$$

For Example, let’s say we want to know the head loss of 3 gpm through ¾” Type L copper. Using the 6’ per 100’ table, the flow rate is 4.2 gpm:

$$\Delta P = \left(\frac{1\,[gpm]}{3.5\,[gpm]}\right)^2 \left(\frac{6\,[ft\,H2O]}{100\,[ft]}\right) = 0.49'per\ 100'$$

The above calculations could be approximated as 0.5’ per 100’ or 1’ per 100’ depending on the experience/discretion of the designer. The above formula is accurate for flow rates +/-20% of those listed.

For more information on PEX-a pressure drop data visit:
ComfortPro Systems Document Center

PRESSURE LOSS CHARTS: STEEL, COPPER, PEX

A summary of pressure loss data for piping comes from ASHRAE. The figures below show pressure (friction) loss for steel pipe, copper pipe, and plastic pipe. PEXa resembles plastic pipe, so the figures are generally accurate.

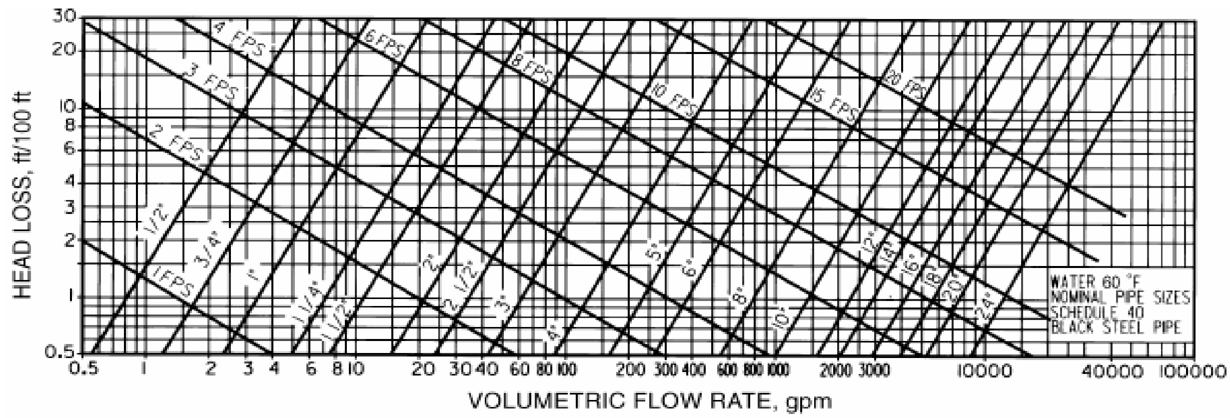


Fig. 4 Friction Loss for Water in Commercial Steel Pipe (Schedule 40)

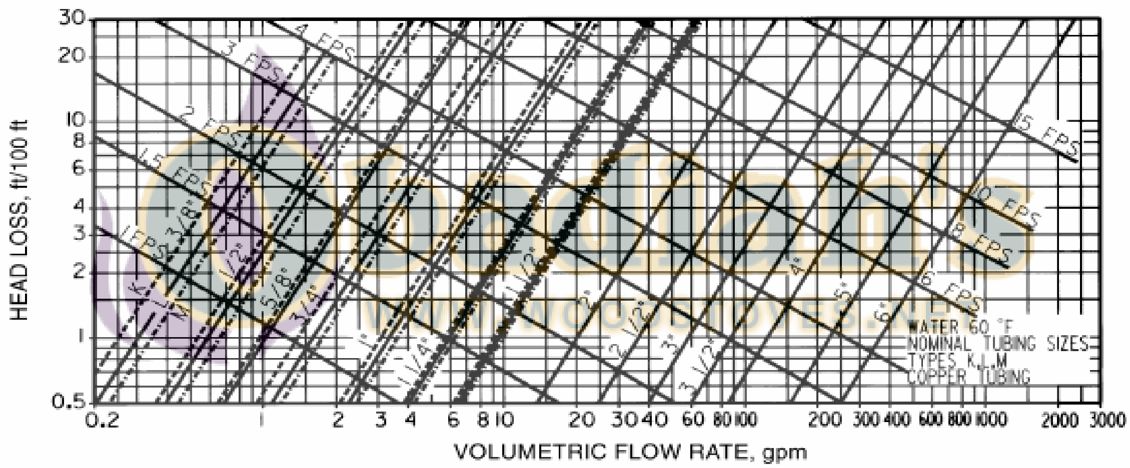


Fig. 5 Friction Loss for Water in Copper Tubing (Types K, L, M)

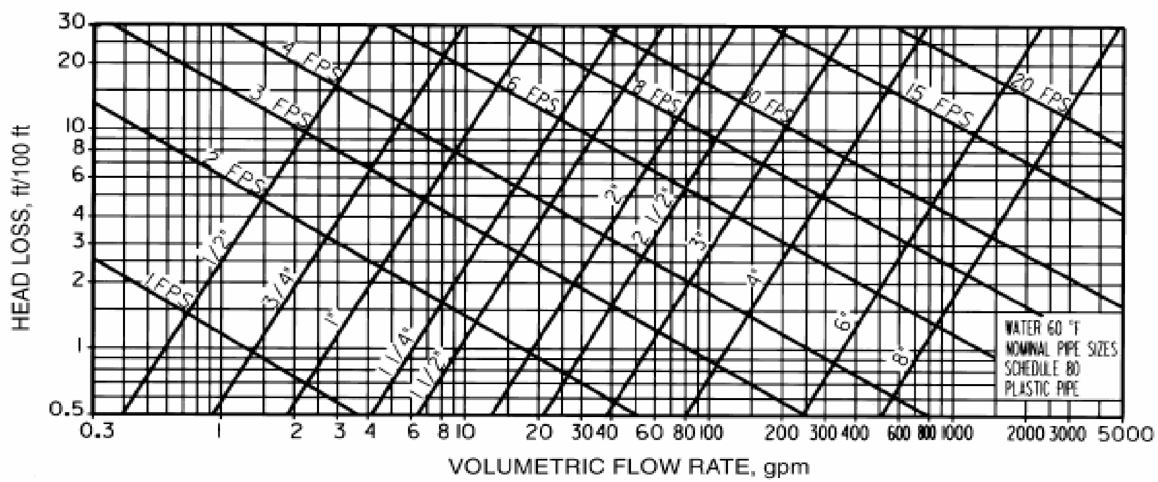
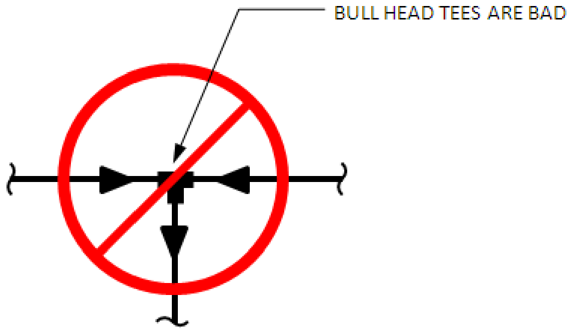


Fig. 6 Friction Loss for Water in Plastic Pipe (Schedule 80)

Reproduced from ASHRAE. (2009). Pipe Sizing. In *Fundamentals* (p. 22.7). Atlanta, GA

PIPING INSTALLATION AND HOOKUP GUIDELINES

- **DO NOT** install polybutylene or PVC plastic pipe.
- Provide pipe support according to plumbing code guidelines.
- After installation, flush all piping to remove, threading oil, solder flux, and debris.
- All check valves and ball valves shall match pipe size. Ball valves shall be full port, if possible.
- **DO NOT** install piping to produce a bull-head tee condition.



- Install accessible shut-off valves on the supply and return pipes near the GARN® WHS unit.
- Install a separate boiler drain at the designated fitting on the front head of the GARN® WHS unit.
- **DO NOT** Install automatic air bleeds in a GARN® or any non-pressurized system. *Install only* *manual air bleeds at all system high points.*
- In new installations, provide a floor drain (with a hose bib if desired) to accommodate the overflow pipe and drain valve.
- Install a domestic water sill cock for adding water near the GARN® WHS unit. A filter housing and filter should be mounted in series with, and adjacent to, the sill cock. Use a hose to fill the unit through the manway opening. **DO NOT** permanently connect the GARN® unit to a domestic water source.
- Install drain valves in the distribution system where appropriate and required to allow future maintenance and equipment repair/replacement.
- Insulate all above grade piping with ½" wall polyolefin pipe or 1" fiberglass insulation rated to 212°F (Thermocel, Imcolock, Imcoshield are preferred brands).

PLUMBING WITH COPPER:

- When installing copper distribution pipe use **ONLY:** long sweep elbows; 95-5 solder or brazing; and die-electric couplings where copper pipe joins steel pipe.
- **DO NOT CONNECT** copper pipe directly to the GARN® unit; electrolytic corrosion will occur.
- Install 4' to 6' of black steel pipe between the GARN® unit and any copper pipe.

PLUMBING WITH STEEL:

- Use 2" black steel pipe between the GARN® unit hot water supply connection and the inlet to the GARN® hot water supply pump.
- If installing steel pipe, use **ONLY** black steel pipe. **DO NOT USE** galvanized pipe.

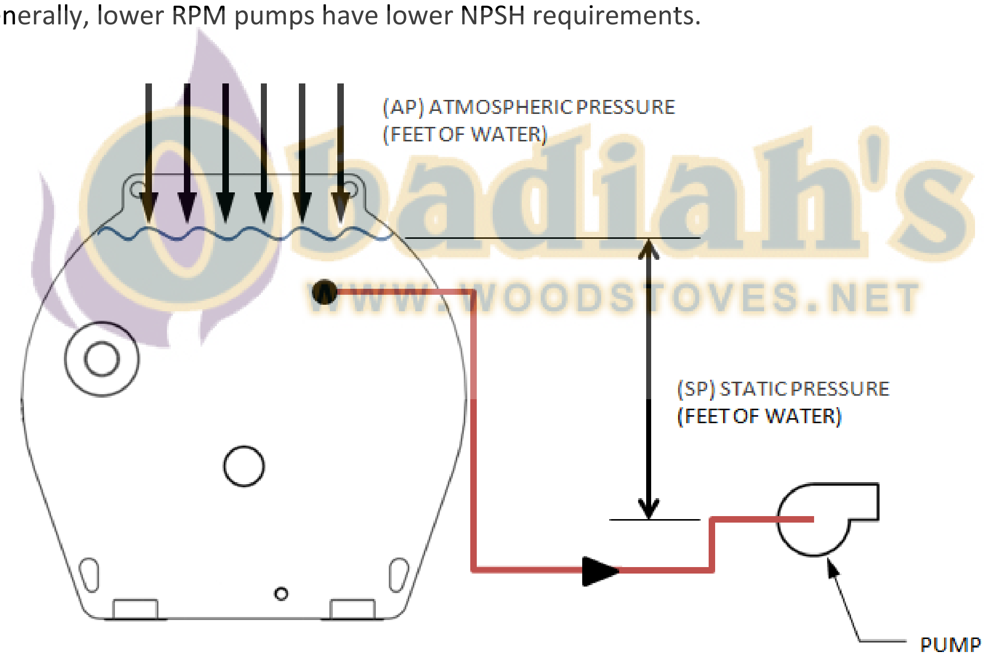
CALCULATION OF NET POSITIVE SUCTION HEAD FOR PUMPS

All GARN® wood heating units are zero pressure closed systems as opposed to:

- Open system – replaces the vast majority of its contained water daily. A good example of this is a domestic water heater.
- Pressurized closed system – replaces little if any of its contained water on a yearly basis and operates with an internal pressure of 15 to 30 PSIG. A good example is a standard hot water boiler that is used for space heating.

A zero pressure closed system does not develop internal pressure due to its unique open vent system. Such systems do replace a minor volume of contained water on a yearly basis. The designer must consider net positive suction head (NPSH) when selecting pumps for such systems. Proper selection will prevent cavitation and suction boiling that can: destroy the pump; prevent the system from attaining its rated heating capacity; or air lock the hydronic system totally.

Graphs of pump performance and net positive suction head requirements are available from pump manufacturers. In all cases, the NPSHA available must be *greater than* the required NPSH for a specific pump. Generally, lower RPM pumps have lower NPSH requirements.



The net positive suction head ***available*** (NPSHA) is calculated:

NPSHA = AP + SP – HL - VP

AP = Job site atmospheric pressure, in feet of water
SP = Static water pressure at the pump, in feet of water
HL = Head loss between GARN® and pump inlet, in feet of water
VP = Vapor pressure at desired HWS temperature, in feet of water

A simple equation for calculating the head loss between the GARN® and the inlet of the pump:

$$HL = \frac{4}{100} * (L + 2 * EL + 1.5 * BV + 3 * GV + 10 * T)$$

L = Length of pipe between the GARN® and the pump inlet
EL = # of 45° and 90° elbows between the GARN® and the pump inlet
BV = # of ball valves between the GARN® and the pump inlet
GV = # of gate valves between the GARN® and the pump inlet
T = # of tees between the GARN® and the pump inlet

HL, is the summation of pipe, fitting, and valve pressure losses between the GARN® unit and the inlet of the pump. All losses are to be calculated at maximum system design flow (GPM).

NPSHA must always be greater than the net positive suction head ***required*** (NPSHR) for the pump at design GPM, or cavitation and suction boiling will occur. The NPSHR is provided by the pump manufacturer (see the *Pump Selection and Installation Guidelines* section of this manual)

The following tables list atmospheric pressure (AP) at various elevations and vapor pressure (VP) at various HWS temperatures.

ATMOSPHERIC PRESSURE (AP)

Elevation (ft)	Atmospheric Pressure (ft)	Boiling Point of Water (°F)
Sea Level, 0	33.9	212
1000	32.8	210
2000	31.5	208
3000	30.4	206
4000	29.2	204
5000	28.2	202
6000	27.2	200
7000	26.2	198

VAPOR PRESSURE (VP)

System Type	HWS Temperature (°F)	Vapor Pressure (ft)
Radiant Floor	90	1.68
Radiant Floor	104	2.47
Radiant Floor	113	3.5
Radiant Floor	125	4.56
Air Coil	125	4.56
European Wall Radiator	140	6.65
Hot Water Baseboard*	150	9.02

* Hot water baseboard can be sized to utilize 140°F HWS

UNDERGROUND PIPING:

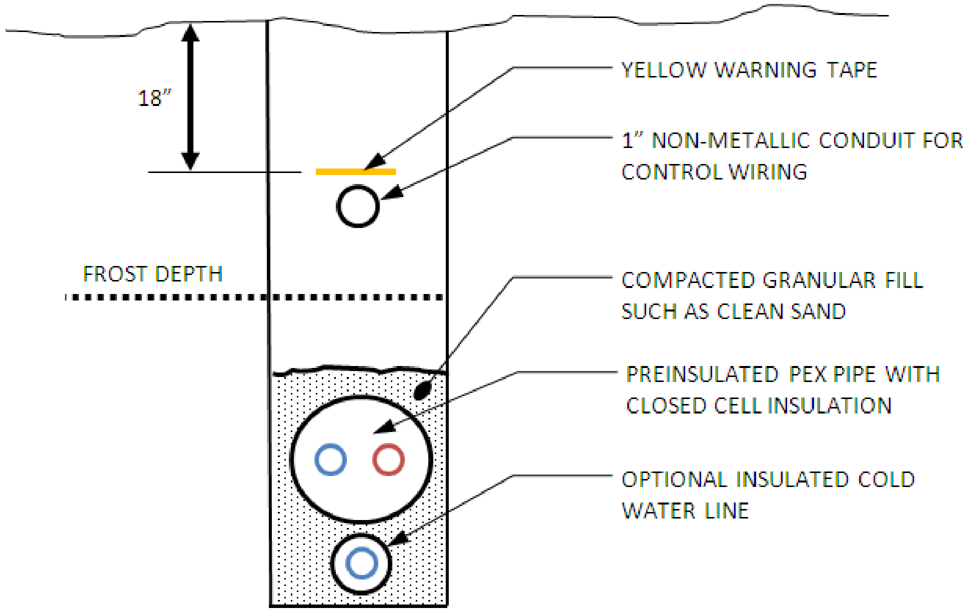
Use only **oxygen barriered,** cross linked, high density polyethylene for underground installation. Pre-insulated PEX pipe manufactured by ComfortPro or Uponor is strongly recommended. Underground piping must be designed to allow for expansion and installed in strict compliance with the manufacturer's specific instructions (such as the Microflex installation guide)

http://www.comfortprosystems.com/pdf/MFInstallGuide2009rev1web.pdf

- **DO NOT** install copper, steel, polybutylene or PVC pipe underground.
- **DO NOT** join pipe underground unless absolutely necessary. If required use **ONLY** materials provided by the pipe manufacturer and installed according to their specific directions.
- In very cold climates place a sheet of 2" thick x 24" to 48" wide foam insulation (blue, pink, yellow or green) board immediately above the pipe, centered on the pipe before back filling the trench. Trench depth in cold climates should be 4 feet (grade to top of pipe) if possible.
- Deeper burial and additional insulation is required when below grade piping extends beneath a parking lot or roadway (frost will normally penetrate the soil to a greater depth in such areas).
- Pressure test for water leaks before back filling the trench.
- If the piping can only be positioned above frost depth, provide a pump timer to circulate water for five to ten minutes every hour during the heating season.
- Avoid burial in continuously wet soils, under creeks, natural land depressions, drainage ponds, etc.

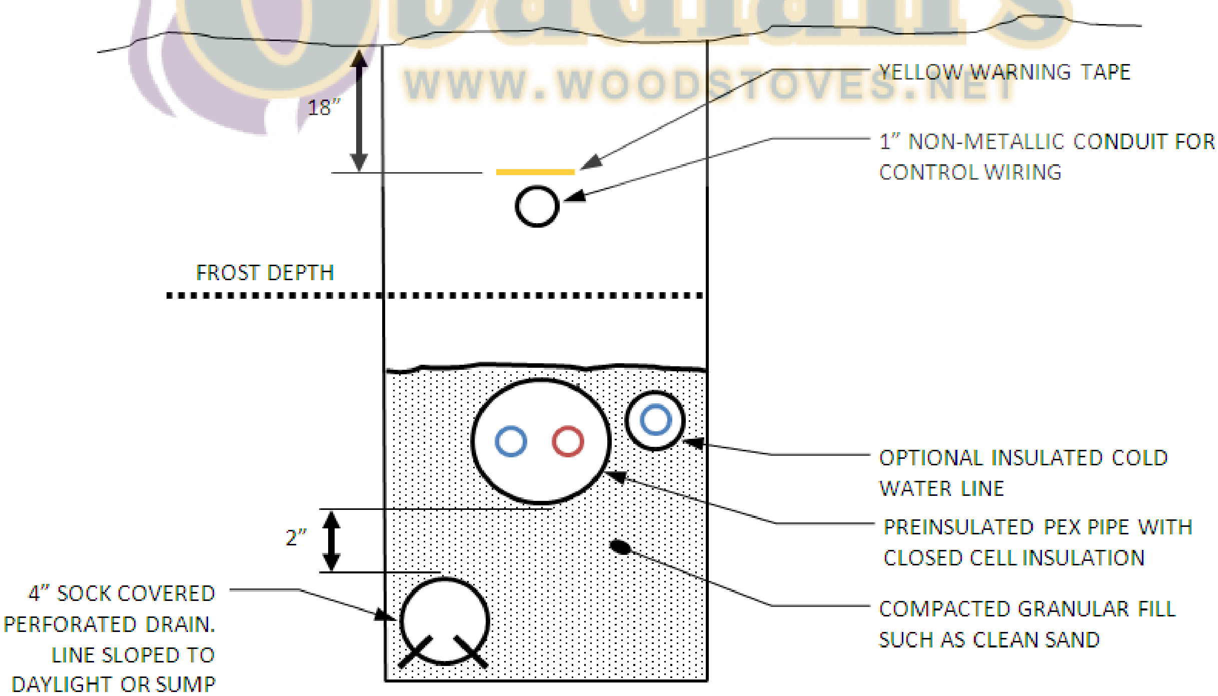
DRY AREA BURIED PIPING DIAGRAM:

- The following diagram shows how preinsulated, underground PEX-a piping shall be laid in dry areas.
- Trench with a "ditch witch" to a depth below the frost line.



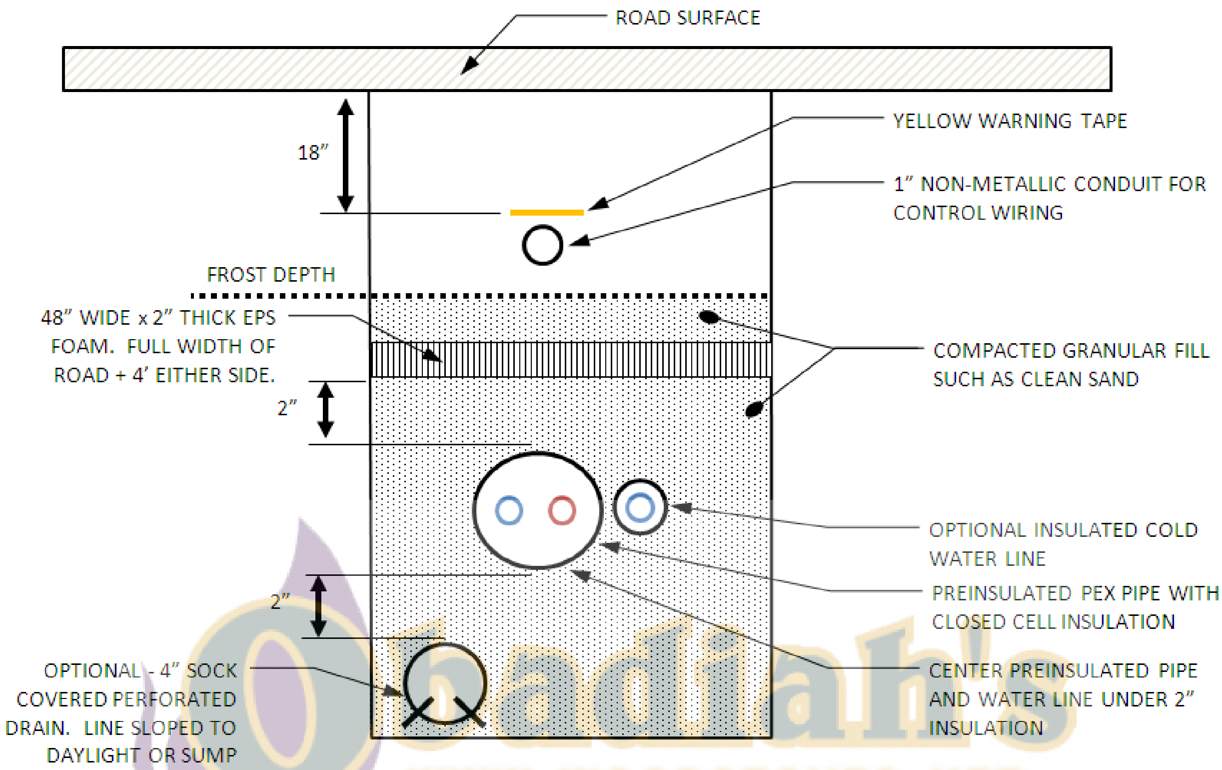
MOIST AREA BURIED PIPING DIAGRAM:

- The following diagram shows how preinsulated, underground PEX-a piping shall be laid in areas where moisture may sometimes be present.



ROADWAY AND PARKING LOT BURIED PIPING DIAGRAM:

- The following diagram shows how preinsulated, underground PEX-a piping shall be laid in areas where snow is routinely cleared (such as below and paved surface where there is vehicle or foot traffic).



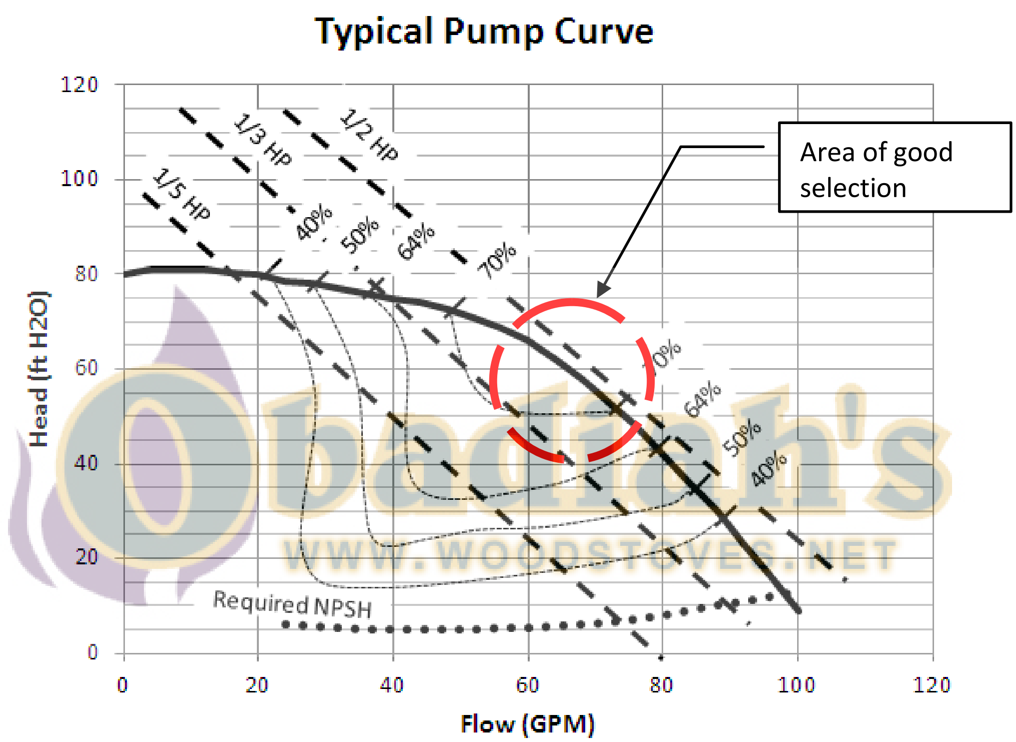
PUMP SELECTION AND INSTALLATION GUIDELINES:

All pumps must be selected based on a **calculated total** static and frictional head loss of the piping connected to the pump as well as the calculated required system flow.

- Preferred pump brands include: Taco, Bell & Gossett, Wilo and Grundfos.
- Select a pump that delivers a flow rate that does not violate the Piping Design and Calculation Guidelines (see previous section) for head loss and fluid velocity. **Size the pump based on a calculated system head loss and system flow requirement – DO NOT guess.**
- All pumps shall be installed in strict compliance with manufacturer's instructions, with particular attention to shaft orientation and the length of straight run of inlet and discharge pipe required to produce stated performance. In most cases, install pumps to discharge **vertically up or horizontally.**
- Provide isolation full port ball valves flanges on the inlet and discharge of the pump.
- Pumps should be located adjacent to the **GARN® WHS** unit if at all possible. Mount pumps at least 4' below the surface of the **GARN® WHS** water level in order to prevent suction boiling at the pump inlet at higher water temperatures. *(See previous section - Calculation of Net Positive Suction Head For Pumps)*
- A heating system may use several zones within a building. Likewise, one **GARN® WHS** unit may supply heat to several buildings. Use individual pumps with check values for each zone (or

building) and develop a common supply manifold to feed the pumps. Likewise, provide a common return manifold. **DO NOT** install manifold piping to produce a bull-headed tee condition.

- In a remote location, zone pumps may be mounted adjacent to the heating system **PROVIDED:** the total head loss (static and frictional) of the supply pipe is equal to or less than 3 feet; and the pump is mounted at least 6’ **below** the surface of the **GARN® WHS** water level. Again, this is necessary to prevent suction boiling at the pump inlet. *(See previous section - Calculation of Net Positive Suction Head For Pumps)*.
- **DO NOT** select a pump to operate near the top of its pump curve as “cycling flow” may occur with resultant damage to the pump and substandard system heating performance. See the figure below.



- In an existing system, the pump size must be confirmed as adequate for the modified system.
- Under-sizing a pump will significantly reduce the performance of the heating system and may allow system piping to freeze.
- When hooking into an existing system, use a primary-secondary setup.

E. SYSTEM DISTRIBUTION CONNECTION AND SCHEMATICS

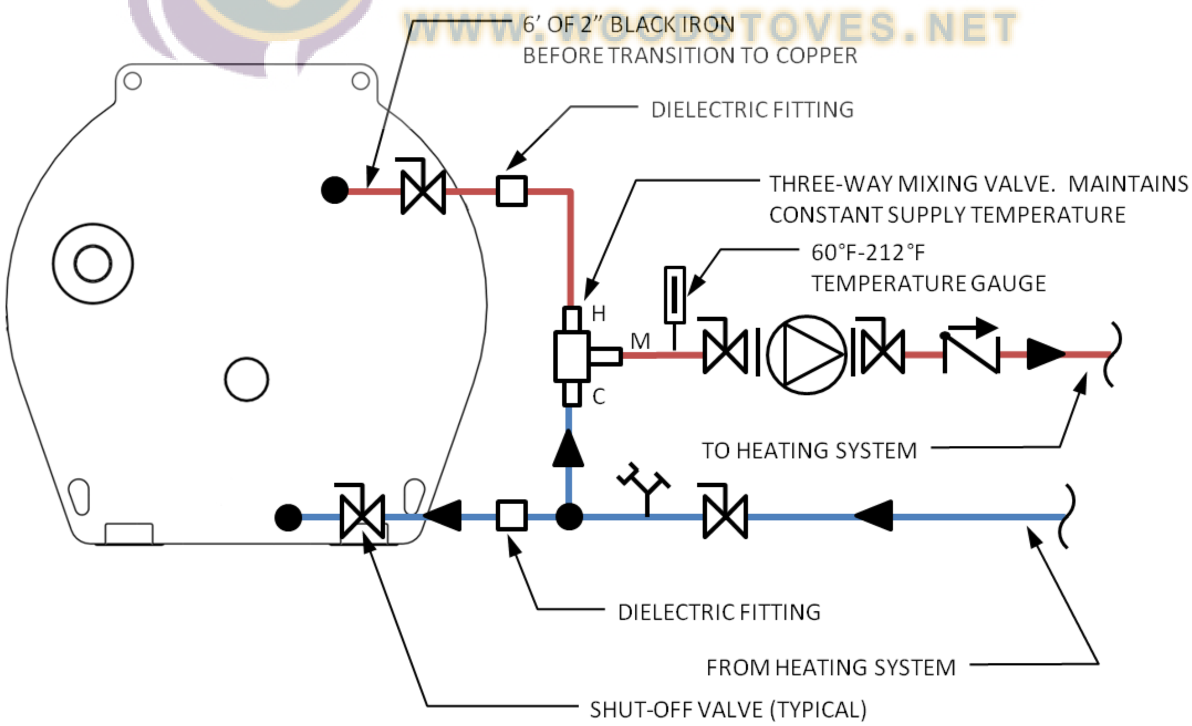
Refer to the drawings on the next few pages for **general** schematics associated with a GARN® WHS unit heating a single building containing either a single zone system or a multiple zone system.

The following drawings are schematics; as such it is neither detailed nor sufficiently complete for construction. Therefore, a comprehensive design must be completed by either an Engineer or Mechanical contractor who is knowledgeable about GARN® zero pressure heating equipment and the particular site conditions for which the schematic is proposed. This schematic is NOT a document of sufficient detail to yield a functioning heating system.

ZERO PRESSURE, FIXED TEMP - PRIMARY ONLY PUMPING:

A zero pressure, fixed temp system delivers a fixed water supply temperature to a non-pressurized hydronic heating system. Such a system is "zero-pressure" because the heating system is in direct contact with the atmosphere at the GARN unit. As the system heats up, the expansion of the water is reflected in the level of the GARN unit.

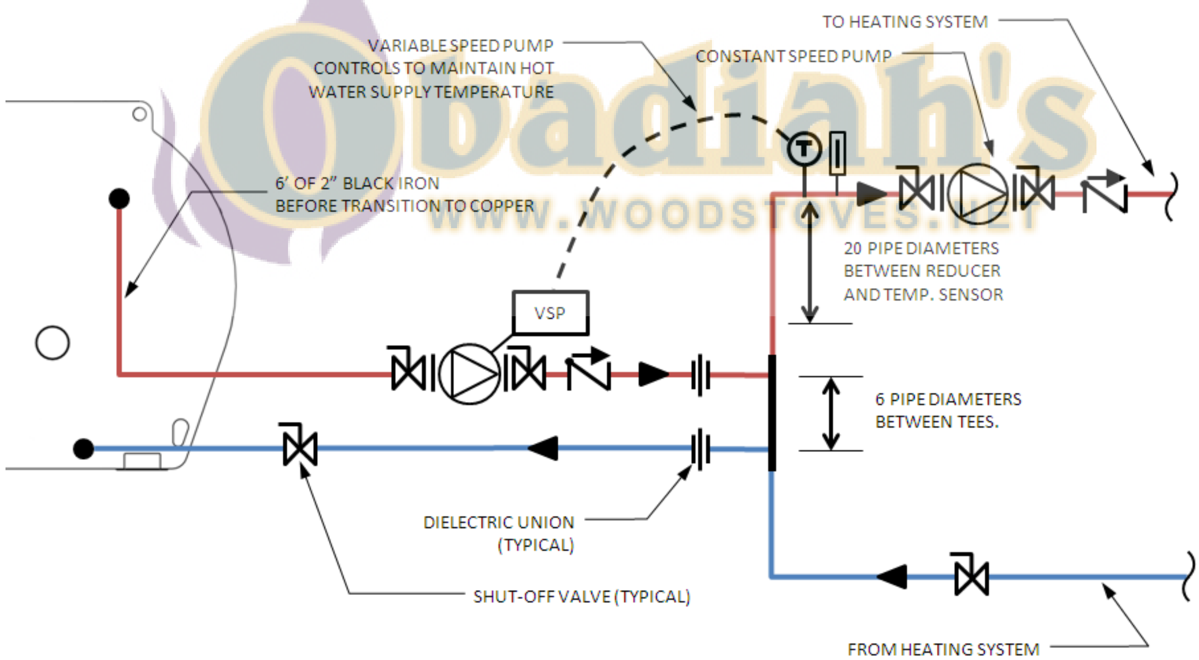
Advantages	Disadvantages
• Simple. • No expansion tank required. • Constant speed or variable speed pump can be used.	• Cannot connect to a pressurized system. • If pumping to a level higher than the level of the GARN unit, the system will drain back to the GARN which could prevent many pipes from remaining "wetted".



ZERO PRESSURE, FIXED SUPPLY TEMP – PRIMARY SECONDARY PUMPING:

A primary-secondary pumping scenario involves two pumps: The *primary* pump circulates water between the GARN unit and the heat distribution piping; the *secondary* pump circulates water through the heat distribution piping.

Advantages	Disadvantages
• The main advantage of this type of system is that it can be directly connected to an existing **zero pressure** heating system. • Temperature and flow can be controlled independently. • Primary loop pump only needs to be sized from the primary loop piping. • Secondary loop pump only needs to be sized for secondary loop piping. • No mixing valve required. • No expansion tank required.	• Cannot connect to a pressurized system. • If pumping to a level higher than the level of the GARN unit, the system will drain back to the GARN which could prevent many pipes from remaining "wetted".



ZERO PRESSURE, MULTIPLE ZONE – PRIMARY SECONDARY PUMPING:

Another pump/piping strategy that can allow for a better control, smaller pumps and fewer design calculations is a “primary secondary pumping system” (refer to the drawing on the following page). This drawing details a single GARN® unit providing heat to two separate buildings, a home and a shop. Note the following:

- Pumps P1 and P3 circulate water from the GARN® WHS unit to a pair of closely spaced tees within each building and then back to the GARN® WHS unit. The two pumps are sized based upon the head loss of the underground piping and the manifolds at the GARN® WHS unit. The head loss for the piping within either building is **NOT** taken into account. This makes for simpler piping head loss calculations when interfacing with an existing system.

The underground piping and the GARN® manifold are considered the **“primary piping loop.”**

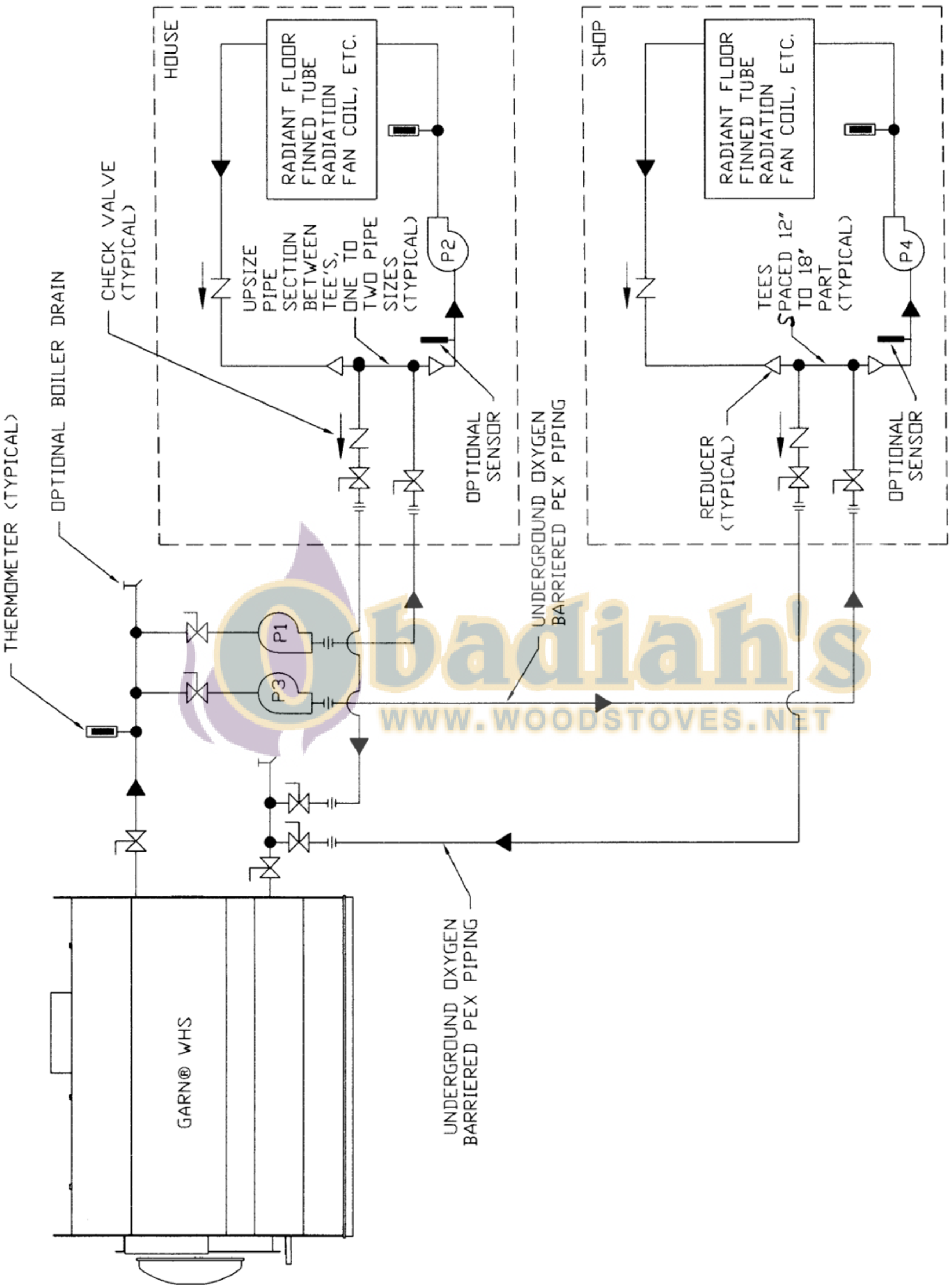
- Pumps P2 and P4 simply circulate warm water (a mixture of cool system return water and hot supply water) to the heat delivery system in the building. The two pumps are sized based upon the piping and equipment head losses within the building **without** taking into account the head loss of the underground piping or the manifold at the GARN® WHS unit. This allows a good match between pumps P2 and P4 and the heat delivery equipment (air coil, hot water baseboard, radiant floor, or any combination thereof). In fact multiple small pumps may be used to split the building into independently controlled heating zones. Again, this makes for simpler piping head loss calculations when interfacing with an existing system because the existing pump generally does not have to be replaced as it experiences no net change in its resistance to flow.

The piping in the building is considered the **“secondary piping loop.”**

One could further increase the energy efficiency of this system by using variable speed pumps for P1 and P3. The speed of the pumps would be controlled by an optional temperature sensor or even an indoor-outdoor reset temperature controller. In this case, with the GARN® WHS unit hot (say 195°F) P1 and P2 would run slowly as only a small volume of hot GARN® WHS water would be required to warm the water within the secondary piping loop. When the GARN® WHS unit was cool (say 125°F) the pumps would provide a greater flow to warm the water within the secondary piping loop.

Some specifics about the closely spaced tees:

- The tees should be **no more than 6 pipe diameters apart**.
- The tees should be located on the return side of any existing hot water heating system.
- Flow between the tees may reverse direction when the secondary system pumps (P2 and P4) are activated.
- The piping reducers are beyond the 12” of pipe and the two tees.
- Activation of P1 and P3 may be interlocked with P2 and P4 except when there is a possibility of the underground piping freezing.


HOUSE
RADIANT FLOOR
FINNED TUBE
RADIATION
FAN COIL, ETC.
P2
UPSIZE PIPE SECTION BETWEEN TEE'S, ONE TO TWO PIPE SIZES (TYPICAL)
CHECK VALVE (TYPICAL)
OPTIONAL SENSOR
SHOP
RADIANT FLOOR
FINNED TUBE
RADIATION
FAN COIL, ETC.
P4
TEES SPACED 12" TO 18" PART (TYPICAL)
REDUCER (TYPICAL)
OPTIONAL SENSOR
THERMOMETER (TYPICAL)
OPTIONAL BOILER DRAIN
P1
P3
UNDERGROUND OXYGEN BARRIERED PEX PIPING
GARN® WHS
UNDERGROUND OXYGEN BARRIERED PEX PIPING

CONNECTING TO AN EXISTING PRESSURIZED OR GLYCOL TREATED DISTRIBUTION SYSTEM:

⚠ CAUTION **DO NOT** connect your GARN® unit to an old, dirty or glycol treated hydronic system until the system has be thoroughly cleaned and flushed.

Conventional hydronic distribution systems with a steel or cast iron boiler, cast iron radiators, copper hot water baseboard, or water to air coils, may contain a sludge or solution that can attack the steel in your GARN® heat storage system. Over time bacteria, debris and/or glycol can transform into this *very corrosive* sludge/solution. This liquid **SHOULD NOT BE MIXED** with the GARN® storage water. Rather the existing system **MUST** be completely drained and flushed with a chemical cleaner before connecting it to the GARN® unit. Contact PrecisionChem for proper chemical and procedures:

Mike Kuzulka @ PrecisionChem Water Treatment
W7231 State Road 49
Waupun, WI, 53963
1-(920)-324-2007 (call with any questions)

⚠ CAUTION Anti-freeze used in distribution systems must be replaced after 3 - 5 years. Anti-freeze slowly degrades over a period of time and transforms into a very aggressive solution that readily attacks steel. Any hydronic system that uses antifreeze **MUST** be periodically checked and the antifreeze replaced *before* it becomes aggressive.

⚠ CAUTION Isolate the GARN® water from the distribution system with a heat exchanger. If the distribution system requires anti-freeze, the distribution system **MUST** be isolated from the GARN® WHS heat storage water with a flat plate or equal heat exchanger.

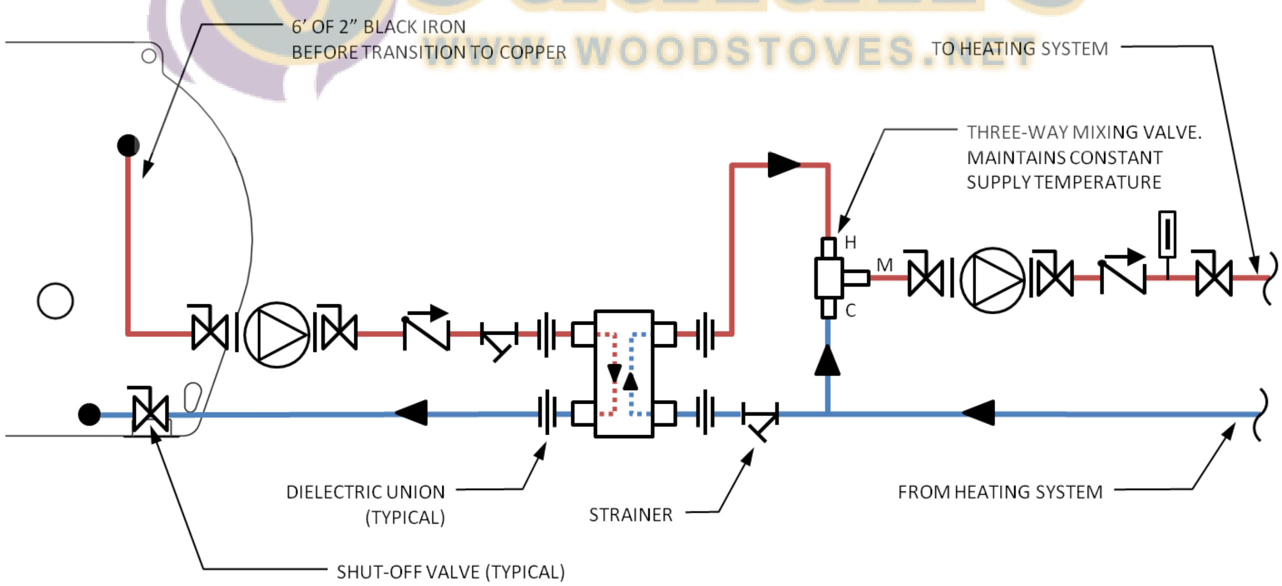
⚠ CAUTION The design and installation of your distribution system may cause the GARN® tank to become sacrificial, if proper procedures are not followed. Connect only black steel pipe to GARN® unit, install dielectric couplings where copper pipe connects to steel pipe, install the chemicals provided and test/maintain your water chemistry twice per year. Sacrificial anode rods further help reduce the potential for this type of corrosion.

Carefully follow all procedures specified in the GARN® WHS Owner's Manual.

PRESSURIZED, FIXED SUPPLY TEMP – CONSTANT SPEED PUMPING

The following piping configuration provides a fixed supply temperature via an adjustable mixing valve and brazed-plate heat exchanger. A heat exchanger separates the system's *primary* (GARN side) from the *secondary* (heat distribution) side. The *primary* pump circulates water between the GARN unit and the heat exchanger; the *secondary* pump circulates water around the heat distribution piping. When the space calls for heat, controls activate both pumps.

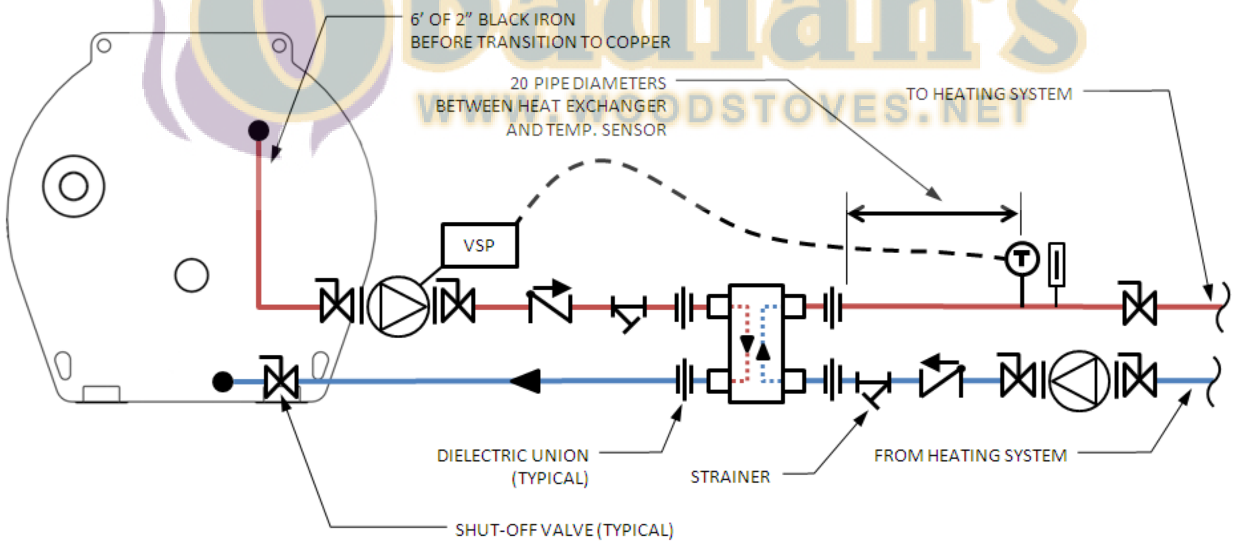
Advantages	Disadvantages
• Can be easily connected to a pressurized system. • Simple and robust, uses constant speed pumps. • The heat exchanger separates the GARN from the heat distribution system, so glycol can be used.	• The heat exchanger must be sized and piped properly. Notice the "counter flow" configuration on the heat exchanger. See discussion in in the Water to Water Flat Plate Heat Exchanger section of this manual. • The strainers must be maintained and cleaned so the heat exchanger does not plug up and lose performance. • If the *primary* pump is improperly sized it can circulate more water than necessary through the GARN unit and the system won't be able to take advantage of thermal stratification.



PRESSURIZED, FIXED SUPPLY TEMP – VARIABLE SPEED PUMPING

The following piping configuration provides a fixed supply temperature via a variable speed *primary* pump and constant speed *secondary* pump. A heat exchanger separates the system's *primary* (GARN side) from the *secondary* (heat distribution) side. The *primary* pump circulates water between the GARN unit and the heat exchanger; the *secondary* pump circulates water around the heat distribution piping. When the space calls for heat, controls activate both pumps.

Advantages	Disadvantages
• Can be easily connected to a pressurized system. • No mixing valve required. • A variable speed pump will only supply as much water as necessary to maintain a set HWS temperature on the secondary side of the heat exchanger. This allows the system to take full advantage of the GARN tank's thermal stratification. • The heat exchanger separates the GARN from the heat distribution system, so glycol can be used.	• The heat exchanger must be sized and piped properly. Notice the "counter flow" configuration on the heat exchanger. See discussion in in the Water to Water Flat Plate Heat Exchanger section of this manual. • The strainers must be maintained and cleaned so the heat exchanger does not plug up and lose performance.



F. SYSTEM COMPONENT CONNECTION AND SCHEMATICS

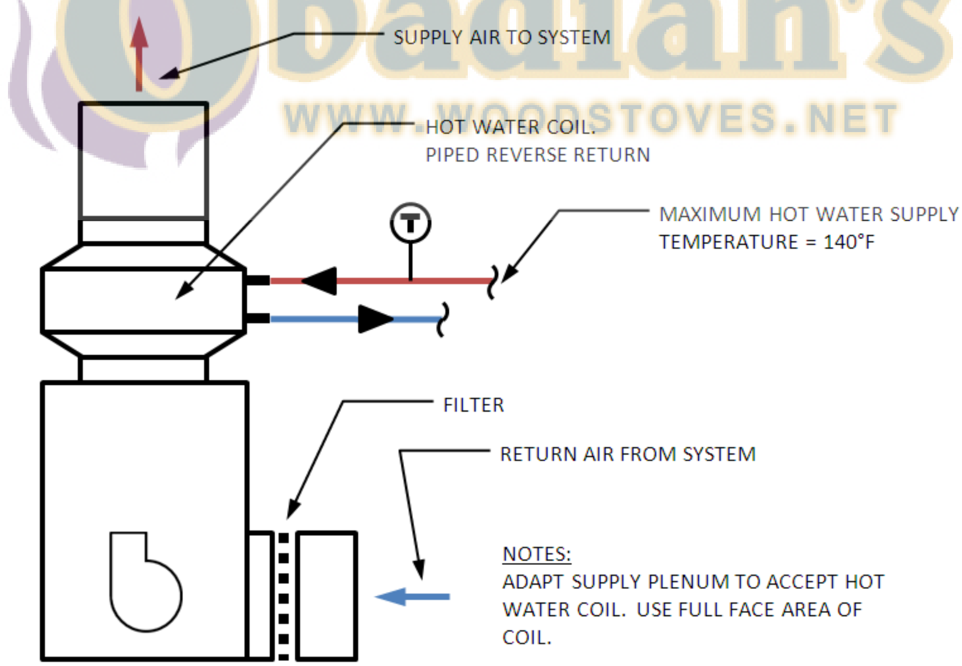
CONNECTION TO FORCED AIR FURNACE:

FORCED AIR GUIDELINES:

A water/air coil may be added to some forced air furnaces or blower cabinets to serve as the primary source of heat. When the room thermostat demands heat, water from the GARN® unit is circulated through the coil and the blower moves air through the coil. In a dual-fuel installation, the thermostat will activate the auxiliary heating unit if there is insufficient heat from the GARN® storage tank.

When adding a water/air coil to any forced air furnace:

- **DO NOT** relocate, modify or rest any of the safety controls in the original furnace installation.
- Blower pulleys and motor pulleys may be changed, but the electrical current flowing through the motor is to be maintained within the nameplate rating. Under some circumstances a larger motor may have to be installed.
- Any water/air coil added to the system must be installed in accordance with the instructions of the manufacturer and in a manner acceptable to the regulatory authority by mechanics experienced in such services.



COIL SELECTION

Check the nameplate on existing heating system for BTU/HR output, blower CFM and allowable external static pressure. Measure the external static pressure with a clean filter in position.

- Choose coil based on desired BTU/HR output and LOWEST entering water temperature (usually 125°F to 130°F EWT).
- Choose circulating pump based on required water flow and total system pressure drop,
- Determine if EXISTING furnace blower is adequate. If NOT adequate, and furnace is in GOOD condition, replace blower assembly or blower motor and pulleys to yield proper flows. If NOT adequate and furnace is in POOR condition, replace the furnace with a new furnace of proper blower capacity. Or replace the furnace with a package fan-coil unit. If the furnace is adequate and in good condition, install the coil.
- **DO NOT** install a coil in a system that utilizes a high efficiency or condensing furnace.
- Call your local GARN® dealer for coil selection and pricing.

HIGH LIMIT SWITCH (DUCT STAT)

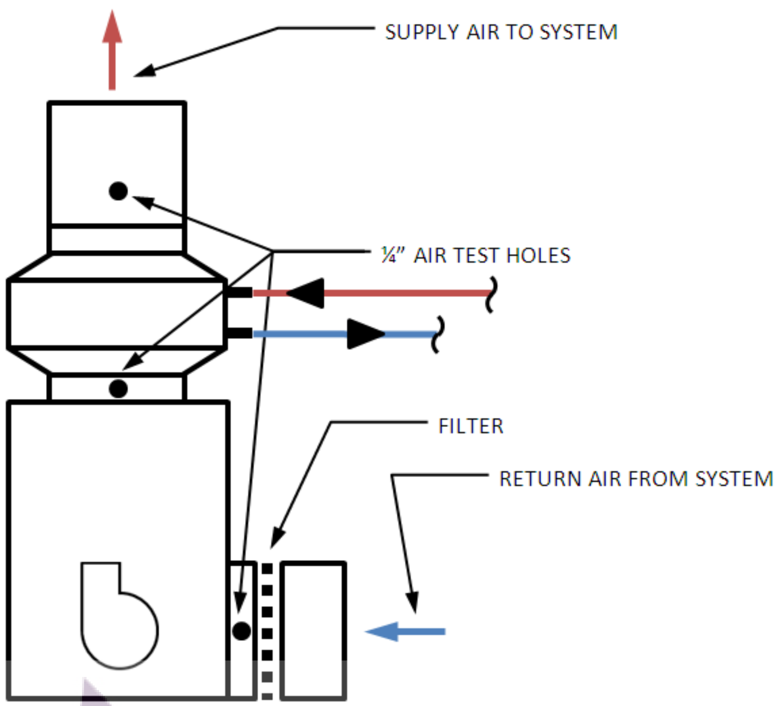
If the HWS temperature to the coil is greater than 140°F an optional high limit switch (sometimes called a duct stat), must be installed on the downstream side of the coil. The duct stat provides overheating protection for the space being heated. If the temperature of air discharged from the coil exceeds 140°F, the switch stops the fluid flow through the coil.

BLOWER SPEED AND CFM ADJUSTMENT

It is very important that the proper air volume is supplied to the heated space, across the furnace's heat exchanger, and across the coil. These air volumes are to be determined by design specifications. A draft gauge reading of pressure drop across the furnace is taken before the coil is installed. This yields the initial system air volume. After the coil is installed, a pressure drop across the coil should be taken to indicate the new system air volume. This new system air volume must be adjusted to supply:

1. The minimum air volume across the furnace's heat exchanger as specified in the manufacturer's engineering data.
2. The proper air volume across the coil to yield the required output
3. The proper air volume to heat the space.

- A minimum of three 1/4" air test holes must be drilled. One in the ductwork on both sides of the furnace and one on both sides of the coil. Refer to following diagram.
- Connect draft gauge across the blower. The zero end of the draft gauge scale connects to the air entering side. Insert the hoses so about 1/4' extends inside the plenum. Seal around holes.



- Start furnace blower motor by placing the thermostat fan switch in continuous position with no heating or cooling demand. Turn on power.
- Refer to the manufacturer's literature for the list of air volumes and equivalent draft gauge readings. Observe draft gauge reading, if reading is below required air volume, increase blower speed. If reading is above required air volume, decrease blower speed. Refer to furnace wiring diagram for changing direct drive blower speed.
- On belt drive blowers, check amperage draw on motor by connecting an ammeter to one leg of the motor supply line and comparing this reading with the full load amps listed on the motor nameplate. The motor pulley must be adjusted **not to exceed** the motor nameplate full load amps for motor installed.
- After required draft gauge readings are obtained, remove draft lines and insert snap hole plugs in air test holes.

CONNECTION TO HOT WATER BASEBOARD SYSTEM:

HOT WATER BASEBOARD GUIDELINES

Install good quality (even commercial grade) hot water baseboard. Sterling® is a preferred brand (http://www.sterlingheat.com/). Cheaper grades produce fewer BTU'S per linear foot of baseboard. Look for copper tube/aluminum finned elements, full back plates and die formed hangers with nylon or roller slides to eliminate noise. In addition:

- Size the baseboard for 140°F supply water temperature and a 20°F temperature drop.
- Circuit baseboards in a parallel configuration so that all elements receive the same 140°F supply water.
- Use copper or oxygen barriered PEX for supply and return piping.

- Size the pump to provide 1 to 1.5 gpm of flow at a maximum velocity of 4 FPS through each baseboard.
- Individual room-by-room control is best. This is easily accomplished by using a radiant floor manifold with individual runouts to each HWBB section. If this is not possible, try to zone the system so that rooms with similar heat loss characteristics are on the same circuit.
- Whenever a zone thermostat calls for heat, the pump serving that zone is to be activated.
- Strictly follow the manufacturer's installation and placement instructions.

NEW CONSTRUCTION

Determine the linear footage of wall that is available for the placement of the hot water baseboard. Divide the BTUH heat loss of the building by the available footage. Select the baseboard units that can supply the BTU's per foot required to meet the building's heat loss. Select the baseboard based on a supply water temperature of 140°F. If the available linear wall footage is not sufficient, adding more baseboard, selecting a more efficient baseboard, or selecting a larger GARN® unit with greater thermal storage is required.

CONVERTING AN EXISTING BASEBOARD SYSTEM

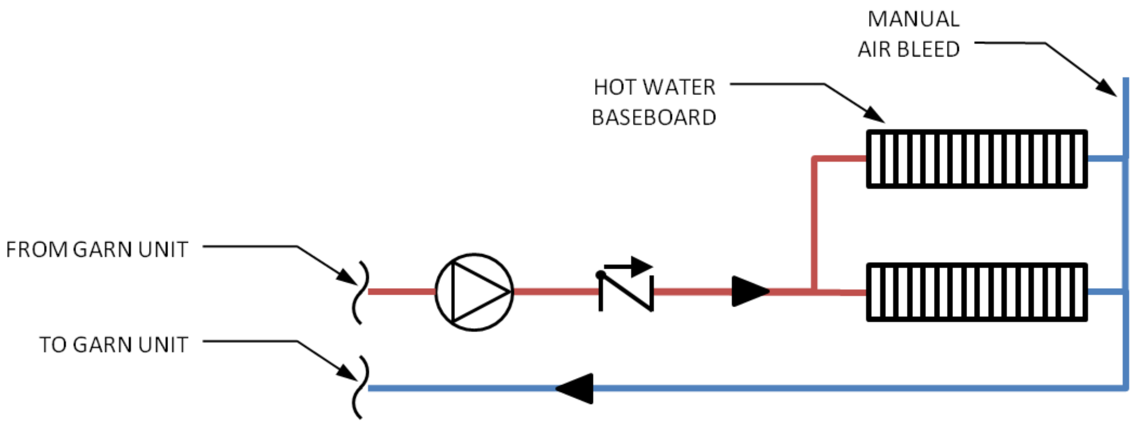
Most installers select a GARN® system that will supply 140°F water to a baseboard system. If the existing system was supplying water at a higher temperature, say 180°F, an analysis must be done to determine whether a lower supply water temperature will meet the needs of the building. The following table can be used for this purpose.

Water Temperature Correction Factors (entering air temperature = 65°F)

Supply Water Temperature (°F)	100	110	120	130	140	150	160	170	180	190	200	210	215
Correction Factor	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.69	0.78	0.86	0.95	1.00

The above table can be used to determine the difference between the BTU/HR delivered by the existing system vs. the BTU/HR that can be delivered by the GARN® system at a lower supply water temperature. A standard of 215°F is used in the industry as the basis for rating. If a baseboard is rated at 1000 BTU's/linear foot at 215°F (contact manufacturer for output ratings), the table indicates that at 180° the existing baseboard can deliver 69% of the rated BTU's or 690 BTU's/linear ft. A GARN® system sized to use 140° water will yield 38% of the rated BTU's or 380 BTU's/linear ft. If the old system was sized twice as large as the actual heat loss (a common occurrence), then the sizing of the GARN® system for 140° water is correct. If more heat is required, a larger storage system or more baseboard footage will be required.

The **drawing below** shows a simple, single zone hot water baseboard system.



CONNECTION TO HYDRONIC RADIANT FLOOR SYSTEM:

RADIANT FLOOR GUIDELINES:

Use only **oxygen barriered,** cross-linked, high-density polyethylene for radiant floor installation. ComfortPro, Uponor, and Roth are the preferred brands. Radiant floor systems must be installed in strict compliance with the manufacturer's instructions. In addition:

- **DO NOT USE** steel, copper, rubber based hose (such as Heatway or Entran tubing), low-density polyethylene, polybutylene or PVC plastic pipe as radiant floor tubing. All of these involve significant and complex corrosion and durability issues for the tubing, pumps, controls, and GARN® equipment.

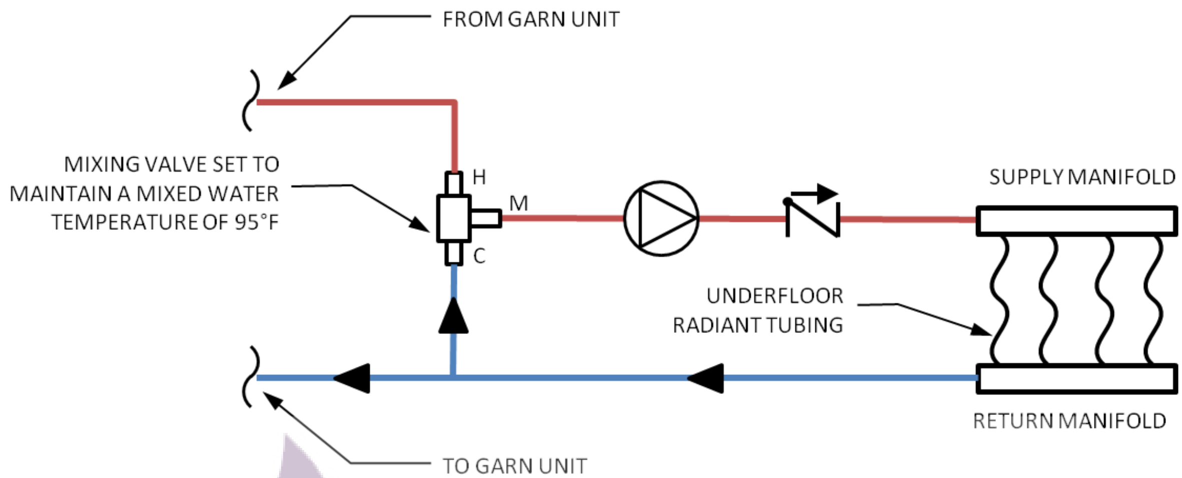
- The installation of rubber based hose (such as Heatway or Entran tubing), low-density polyethylene, polybutylene or PVC plastic pipe in a radiant floor system directly connected to a GARN® unit will void the GARN® and pump warranty.

- In new construction, install 2" of blue, yellow, green or pink foam board (**extruded** polystyrene foam – minimum of 1.6 PCF density, per ASTM C 578-95 specification) under the **entire** slab that is to be radiantly heated. The foam should be placed immediately below the bottom of the slab, on 6" of well compacted granular fill. This construction provides a proper structural bed (compacted gravel) and minimizes downward heat loss.

- When radiant heating is installed on above grade floors, the underside of the floor **MUST** be insulated to prevent downward heat loss and overheating of the rooms below. A minimum insulation valve of R =13 is recommended.

- The radiant floor manifolds supplied by the manufacturers listed, provide for room-by-room control while using only a single pump and mixing valve.

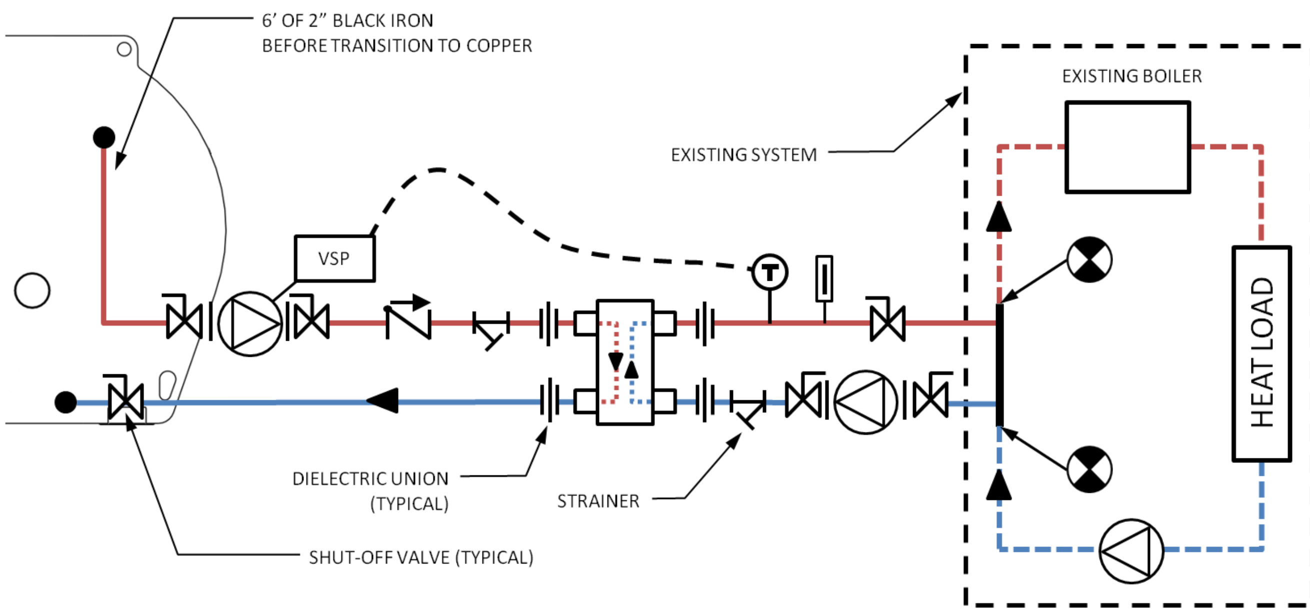
- Install a 3 way mixing valve to blend cooler radiant floor return water with hot supply water from the GARN® unit in order to maintain the moderate supply water temperatures (between 95°F and 130°F) required for radiant floor heating. Mixing valve brands are Paxton ESBE, Honeywell Sparco and Watts. Install mixing valve between the GARN® unit and pump so that the pump draws through the valve from the GARN®.



CONNECTION TO AN EXISTING PRESSURIZED SYSTEM

Retrofitting a GARN® WHS unit to an existing pressurized heating system requires the installation of a pressure rated flat plate heat exchanger. Contact your local GARN® dealer or DECTRA CORPORATION for sizing, availability and pricing of FlatPlate heat exchangers. Note the following and review the drawing:

- DO NOT connect any GARN® unit to a steam boiler or steam heating system.
- The water-to-water heat exchanger must have a pressure rating that is equal to or greater than the pressure rating of the existing boiler. Consider changing the system to a primary secondary system.
- Position the heat exchanger on the return side of the existing boiler.
- The GARN® unit and the heat exchanger shall NOT be installed so as to interfere with the normal delivery of heated water from the existing boiler.
- The GARN® unit and the heat exchanger shall be installed without changing the function of the controls or rewiring the existing boiler. A control wiring connection is permitted only if required to obtain proper operation. For instance, when a thermostat calls for heat, both the GARN® pump and the existing pump are to be powered.
- The electrical system of the existing boiler and GARN® pumps must be powered from a single branch circuit, without exception.

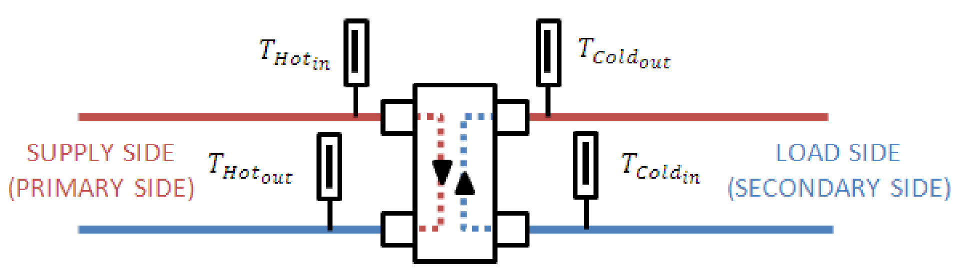


The following table is used to determine an *initial* heat exchanger size. A final selection should be made with the manufacturer's computer selection software. DECTRA CORPORATION can provide this service.

WATER TO WATER FLAT PLATE HEAT EXCHANGERS

MODEL	BTUH OUTPUT	REQ'D GPM	FITTING SIZE	PRESSURE DROP, FEET	STRAINER SIZE	MIN PIPE SIZE
5 X 12 - 16	25,000	3	3/4"	3'	3/4"	3/4"
5 X 12 - 24	50,000	5	1"	3'	1"	1"
5 X 12 - 30	75,000	7.5	1"	3'	1"	1 1/4"
5 X 12 - 36	100,000	10	1 1/4"	4.5'	1 1/4"	1 1/4"
5 X 12 - 50	125,000	12.5	1 1/4"	3.5'	1 1/4"	1 1/4"
5 X 12 - 50	150,000	15	1 1/4"	4'	1 1/4"	1 1/4"
10 X 20 - 30	200,000	20	1 1/2"	6'	1 1/2"	1 1/2"

- BTUH output listed is based on a 10°F approach temperature (see diagram for explanation):



$$\Delta T_{Approach} = (T_{Hot_{out}} - T_{Cold_{in}}) = 10°F$$

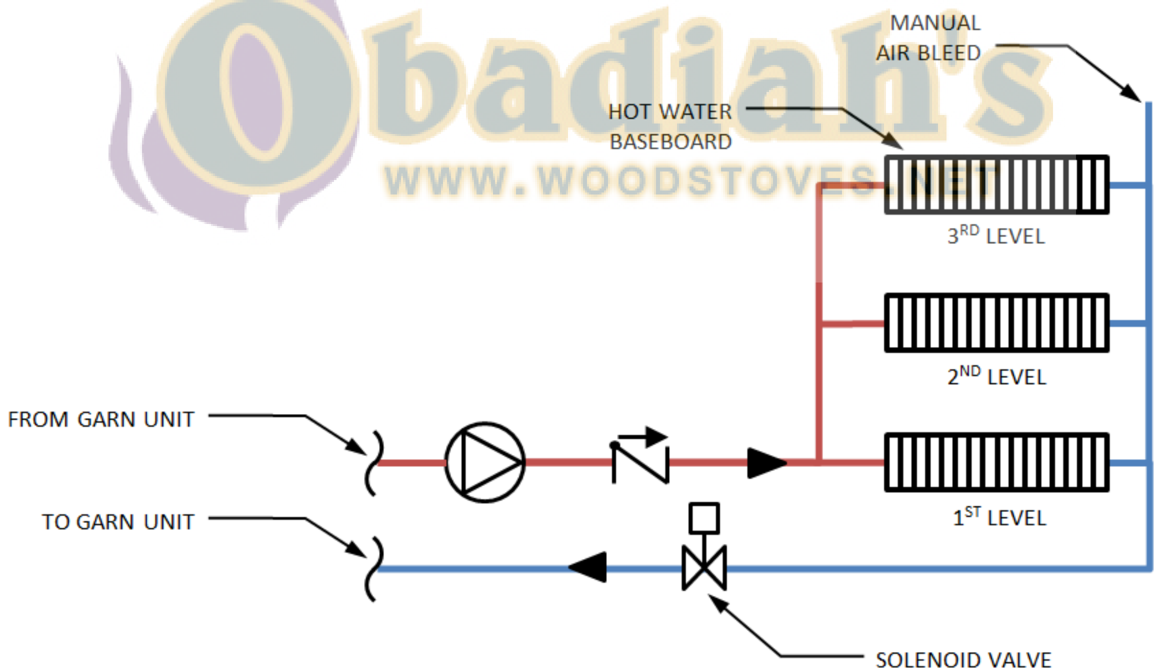
- All unites are pipe counter flow according to their manufacturer's rules.
- BTUH output listed assumes no glycol.
- Larger heat exchanger sizes and units for use with glycol based systems are available. Contact the DECTRA CORPORATION for specific sizing.

- The pipe size indicated is the minimum pipe size based on 4' of head loss per 100' of pipe.

CONNECTION TO AN ELEVATED SYSTEM

Even though the **GARN® WHS** unit is non-pressurized, it is adaptable to heating systems that are elevated up to 16' above the level of the slab on which the GARN® unit sets. If the vertical distance is greater than this, a flat plate water-to-water heat exchanger must be installed (refer to "Connection to an Existing Pressure System). Note the following and review the drawing:

- This type of system is found mostly in warehouses with high ceilings and in multiple floor residences or small commercial facilities.
- All piping and flanges **MUST** be airtight or this type of installation will not function properly. Air leaks will constantly bleed air into the system (negatively affecting both system performance and corrosion).
- **DO NOT** use automatic air bleeds in the heat delivery system. ***Install only manual air bleeds.***
- Select pump to overcome total head, i.e., pipe friction and vertical elevation. Pump sizing is very critical in this application.
- Install a solenoid valve that is energized to open when the pump is powered. This valve is to close whenever the pump is not powered. The valve locks the water in vertical loop when the pump is not operating.
- Install a reliable full-port, spring check valve downstream of the pump.



CONNECTION TO DOMESTIC HOT WATER

Heating of domestic water is easily accomplished with GARN® equipment. In-tank copper water heating coils are **NOT** provided in the GARN® tank for several reasons:

- A copper coil in any steel boiler creates electrolytic corrosion, leading to early tank failure.
- With a coil inside a remote boiler, two additional below grade insulated domestic water lines are required (a supply and return line that connects the coil to the water heater). This adds significant cost to the project.

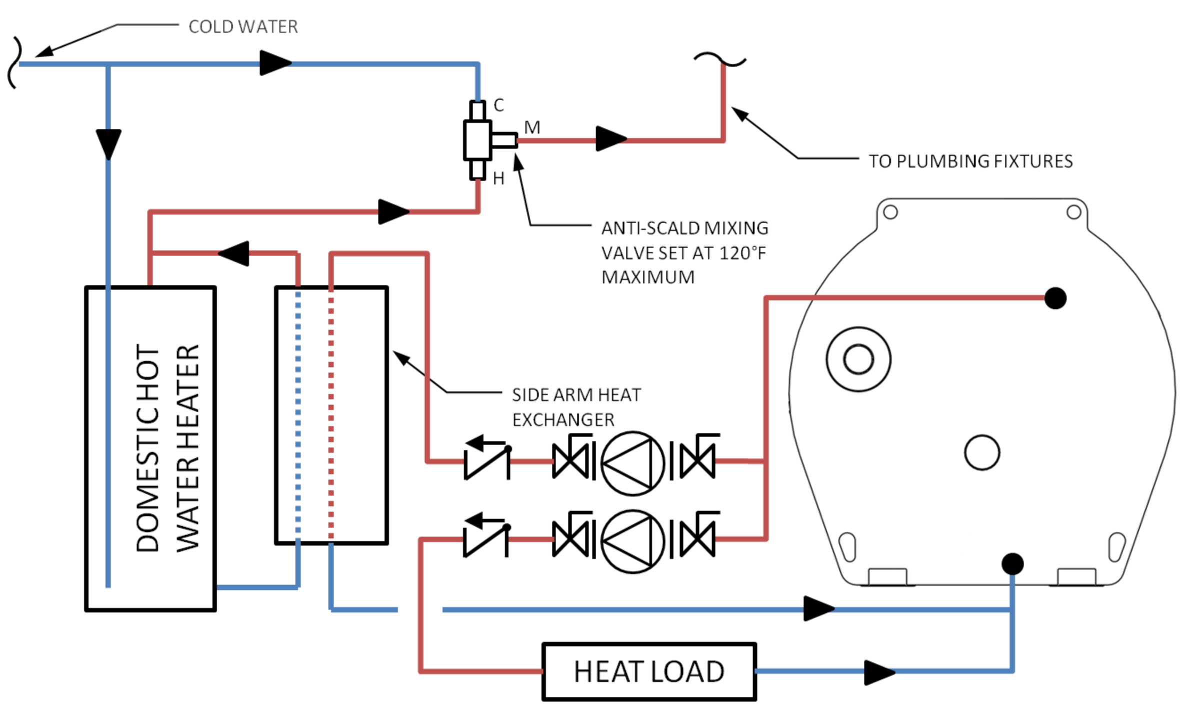
Any domestic hot water heating system must comply with the following rules:

- All domestic water piping, valves, fittings, pumps, controls and the overall installation must meet all national and state plumbing, sanitation and health codes.
- After installation is complete, the entire domestic waterside of the system must be pressure tested, flushed, and then sanitized according to local health department requirements.
- In all cases, a NSF or Board Certified **anti-scald mixing valve** is required by national and state codes when preheating or heating domestic water with equipment other than a conventional water heater. The valve shall be set to deliver hot water at a temperature of 120°F maximum.

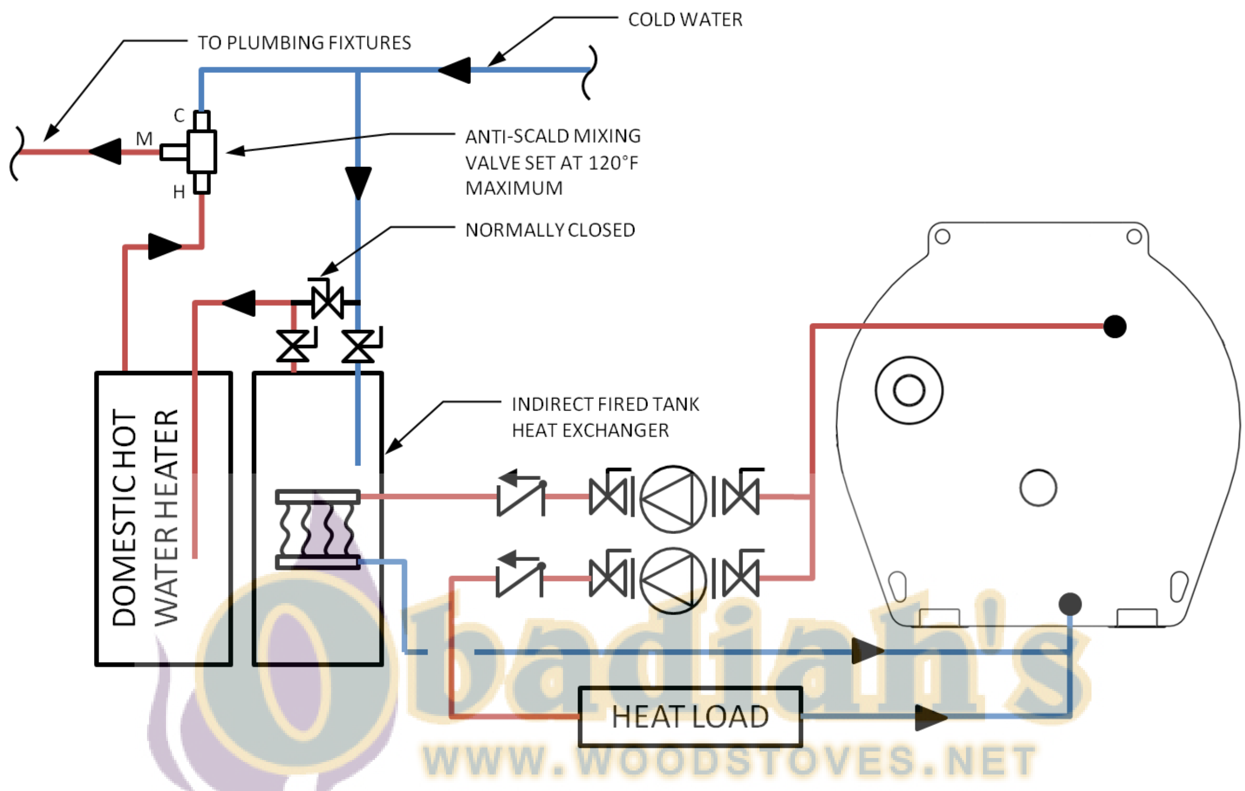
The two methods of preheating domestic water include:

1. **An external "saddle mounted" or "side-arm" heat exchanger**. A double walled, leak detecting tube within a tube all copper water-to-water heat exchanger is the recommended "saddle type" heat exchanger. This heat exchanger is to be mounted, close to and slightly below the level of the top of the existing water heater. Saddle heat exchangers can be installed to thermo-siphon or use a pump on the domestic waterside.

- Install a differential thermostat to control the small (1/25 hp) system pump. The domestic water within the water heater should be heated to 145°F in order to kill water borne Legionelle bacteria. The "hot sensor" of the control should measure the GARN® water temperature; the "cold sensor" should measure the domestic water temperature at the inlet of the heat exchanger. The sensors may be "strapped" to the pipe and covered with insulation in order to provide accurate temperature readings to the differential controller.



2. **A stand alone “indirect fired” tank heat exchanger**. Indirect fired tank heat exchangers generally include a stainless steel internal coil within an insulated stainless steel tank. This unit is then connected in series upstream of the existing water heater. Contact your GARN® dealer for sizing, availability and pricing of a preheat unit. The following applies to any domestic water heating system:



For more information on indirect fired water tanks visit:
http://www.triangletube.com/
http://www.weil-mclain.com/
http://www.heat-flo.com/

SOLAR INTERFACE:

GARN® equipment can be ordered factory ready to connect to solar collectors. The collector with the simplest interface is the drain-back solar collector. Water is pumped from the GARN® unit to the collector, is circulated through the collector, and then drained back into GARN® unit via gravity. The optional ¾” FPT flanged fitting on the left side of the manway collar is the drain back fitting where the return line from the collectors is to be connected.

Some solar collector designs utilize a collector non-water based medium in lieu of water. Such collectors require a heat exchanger to interface with the GARN® unit.

Refer to manuals and data provided with the solar collectors regarding proper installation.

G. BACKUP HEATING WITH THE EXISTING SYSTEM OR ELECTRIC

If the GARN® unit is being added to an existing building, the existing heating system will normally be used as a backup system. Off peak electric heating is available as part of the GARN® unit to serve as a backup to the wood heating. Some utility companies offer discounted electric rates to installations using electric heat with heat storage equipment. Contact your local utility about various programs. Then contact your GARN® dealer for electric backup heating options.

H. EXAMPLE PROBLEM – HOUSE WITH REMOTE POLE BARN/WORKSHOP

The following example problem uses the tools in this manual to size piping, pumps, and GARN® heating equipment for a typical house with a pole barn/workshop.

EXAMPLE PROBLEM SETUP:

House:

- Main floor – 1100 sq. ft - hot water base board (HWBB)
- Basement – 1100 sq. ft – radiant floor
- Newer construction – built in 2007

Shop:

- Pole barn (where GARN® unit is to be located)
- 30' x 40' = 1200 sq. ft
- Radiant floor
- R19 walls, R38 ceiling, R10 underslab insulation
- 1 – 8'x10' overhead door
- 1 – Personnel door
- 3 – 3'x4' windows
- Located 127' from house

HOUSE DESIGN:

- Estimate heat load (see "Rules of Thumb for an Initial Estimate of Equipment Size")

$$Heat\ Load = 1100[sq.ft]18\left[\frac{btuh}{sq.ft}\right] + 1100[sq.ft]12\left[\frac{btuh}{sq.ft}\right]$$

$$Heat\ Load = 19{,}800 + 13{,}200$$

$$Heat\ Load = 33{,}000\ [btuh]$$

MAIN FLOOR DESIGN:

- HWS = Choose 145°F
- ΔT = 10°F
- HWR = 135°F
- HWBB – rated at 980 btuh/ft at 215°F
- HWBB correction factor = 0.38 (see "Water Temperature Correction Factors")

$$HWBB\ Output = 0.38 * 980\left[\frac{btuh}{ft}\right]$$

$$HWBB\ Output = 373\ \left[\frac{btuh}{ft}\right]$$

- Total feet of active fin tube = $\frac{19800\ [\text{btuh}]}{373\left[\frac{\text{btuh}}{\text{ft}}\right]} = 53\ ft$

The total feet of active fin tube needs to be divided up among the main floor rooms based on a calculated heat loss for each room. The fin tube can be roughly split:

ROOM	AREA (sq. ft)	FIN TUBE LENGTH (ft)
Eat in Kitchen	204	10’
1-1/2 Baths	100 (total)	5’
3 Bedrooms	156 (each)	8’ per room
Living Room	280	14’
Hall	48	0’ (no load – internal)
	Total	53’

Main Floor Flow Calculations

$$BTUH = 500 * GPM * \Delta T$$

$$\frac{19800\,[btuh]}{500 * 10[°F]} = 4\,[gpm]$$

However, the minimum flow through any run of HWBB is typically = 1 gpm, with NO more than 20’ of HWBB in any single run. Therefore:

Kitchen: 10’ < 20’ = 1 gpm
1-1/2 Bathrooms: 5’ < 20’ = 1 gpm
Living Room: 14’ < 20’ = 1 gpm
Bedrooms: 8’ each < 20’ = 1 gpm per bedroom (3 gpm total)

6 gpm total required

A radiant floor manifold can be used with HWBB or wall mounted panel radiators to provide for individually controlled zones. In this case each bedroom could be a single zone with the remainder of the main level a single zone for a total of 4 zones. See the following diagram:

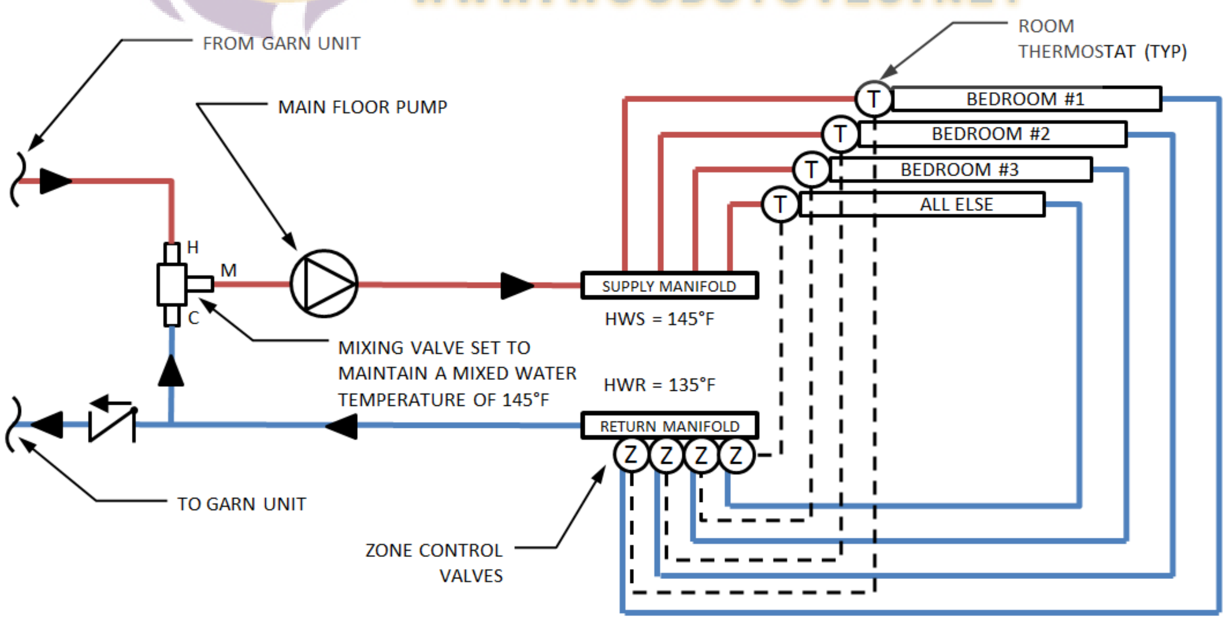


Figure 1: Main Level Floor Manifold Schematic

Use wall-mounted thermostats with manifold mounted zone control valves with end switch.

BASEMENT LEVEL DESIGN:

- Assume no carpet
- 1 zone radiant floor

From radiant floor manufacturer's data:

- Install radiant loops 12" on center
- The manufacturer chosen for this example recommends a maximum loop run of 300' for ½" PEX. The maximum loop length varies from manufacturer to manufacturer and by pipe size. See "Radiant Floor Heating" section of this manual.
- Average loop temperature required is 85°F
- HWS = 90°F (for a bare, concrete floor)
- ΔT = 10°F

Calculate the # of loops of ½" PEX:

$$\frac{1100\,[sq.ft]}{275\left[\frac{sq.ft}{loop}\right]} = 4\ loops\ @\ 275'\ per\ loop$$

Basement Flow Calculations:

$$BTUH = 500 * GPM * \Delta T$$

$$Basement\ Flow = \frac{13{,}200\,[btuh]}{500 * 10[°F]} = \mathbf{3}\,[\boldsymbol{gpm}]$$

$$\frac{3\,[gpm]}{4\ PEX\ loops} = 0.75\left[\frac{gpm}{loop}\right]$$

SIZE THE MAIN FLOOR HOUSE PUMP

Each HWBB section includes a 3/4" copper fin tube element. At 1 gpm, head loss for 3/4" copper is about 0.5' per 100' (see, "Flow and Heat Capacity Tables"). The head loss for 1/2" PEX at 1 gpm is approximately 3' per 100'.

HWBB Loss	$14'\left(\frac{0.5'}{100'}\right) = 0.07'$
1/2" PEX	$2 * 20'\left(\frac{3'}{100'}\right) = 1.2'$
Radiant Manifold	2'
1" Copper Feed to Manifold	$26'\left(\frac{4'}{100'}\right) = 1.04'$
1" Mixing Valve	4'
Subtotal	8.31'
Misc Fittings	10%
Total Head Loss	9.14'

Size the house pump for 6 gpm @ 9.14'

Choose a Taco **007-IFC** variable speed pump with pump control center and room thermostat. For more information see:

TACO® HVAC 007-IFC Circulator
TACO® 007-IFC Performance Curve

SIZE THE BASEMENT PUMP

275' of ½" PEX @ 0.75 gpm	$275'\left(\frac{2.5'}{100'}\right) = 6.8'$
Radiant Manifold	2'
1" Mixing Valve	4'
¾" Copper Feed 20'	$20'\left(\frac{0.5'}{100'}\right) = 0.1'$
Subtotal	12.9'
Misc Fittings	10%
Total Head Loss	14.2'

Size the house pump for 3 gpm @ 14.2'

Choose a Taco **0015** 3-speed pump with pump control center and room thermostat. Set pump to speed 2. For more information see:

TACO® HVAC 0015 Circulator
TACO® 0015 Performance Curve

DISTRIBUTION PIPE AND PUMP SIZING

Total Flow = 6 (main floor) + 3 (basement) = 9 gpm

The owner desires to locate the GARN® unit in a pole barn shop. The shop is 127' from the house. What size MicroFlex® PEX is required? Compare 4' per 100' of head loss to 6' per 100' for the distribution piping:

4' per 100' use 1-1/4" MicroFlex® Duo PEX
6' per 100' use 1" MicroFlex® Duo PEX

Assume the MicroFlex® is buried below the 4 ft. frost line in Minnesota. Therefore, about 6' must be added to the GARN® end and 2' to the house end where the pipe enters the basement.

1-1/4" Head Loss = $(127' + 8')\left(\frac{4'}{100'}\right) * 2 = 10.81'$ Cost = 28 cents/ft

1" Head Loss = $(127' + 8')\left(\frac{6'}{100'}\right) * 2 = 16.20'$ Cost = 19 cents/ft

- Choose the 1" MicroFlex to save money on the initial install.

SIZE DISTRIBUTION PUMP

MicroFlex®	16.2’
1-1/4” Copper @ GARN®	$10'\left(\frac{6'}{100'}\right) = 0.6'$
2” Steel @ GARN®	$10'\left(\frac{4'}{100'}\right) = 0.4'$
Mixing Valve	4.75’
Subtotal	22’
Misc Fittings	10%
Total Head Loss	24.2’

Size the house pump for 9 gpm @ 24.2’

Choose a Taco **0011-IFC** variable speed pump with pump control center. Activate pump whenever house pump activates and set to maintain ΔT=10°F. For more information see:

TACO® HVAC 0011-IFC Circulator
TACO® 0011-IFC Performance Curve

POLE BARN DESIGN

Estimate the heat loss (using ASHRAE methods):

$$Walls = (2*40+2*30)*12'\left(\frac{1}{19}\right)*(72-(-12)) = 7427\ [btuh]$$

$$Roof = 1200*\left(\frac{1}{38}\right)*84 = 2653\ [btuh]$$

$$Overhead\ Door = 8'*10'*55 = 4400\ [btuh]$$

$$Windows = 45*3'*3'*4' = 1620\ [btuh]$$

$$Floor = 1200*0.75 = 900\ [btuh]$$

$$Personel\ Door = 3'*7'*55\left[\frac{btuh}{sf}\right] = 1155\ [btuh]$$

Total Heat Loss = 18,155 [btuh]

Notice that the overhead door, personnel door, and windows are 39.5% of the total loss.

From a Radiant Floor Design manual for 5/8” tubing at 12” on center:

- Surface temperature = 76°F
- EWT = 85°F; RWT = 75°F; Avg. water temperature = 80°F
- Assume no glycol

Maximum length for 5/8” PEX tubing = 450’. Calculate # of loops for 5/8” PEX:

$$\frac{1200\ [sq.ft]}{450\ \left[\frac{sq.ft}{loop}\right]} = 3\ loops\ @\ 400'\ per\ loop$$

$$Pole\ Barn\ Flow = \frac{18{,}155\ [btuh]}{500 * 10[°F]} = 3.6\ [gpm]$$

$$\frac{3.6\ [gpm]}{3\ PEX\ loops} = 1.20\ \left[\frac{gpm}{loop}\right]$$

See the following diagram:

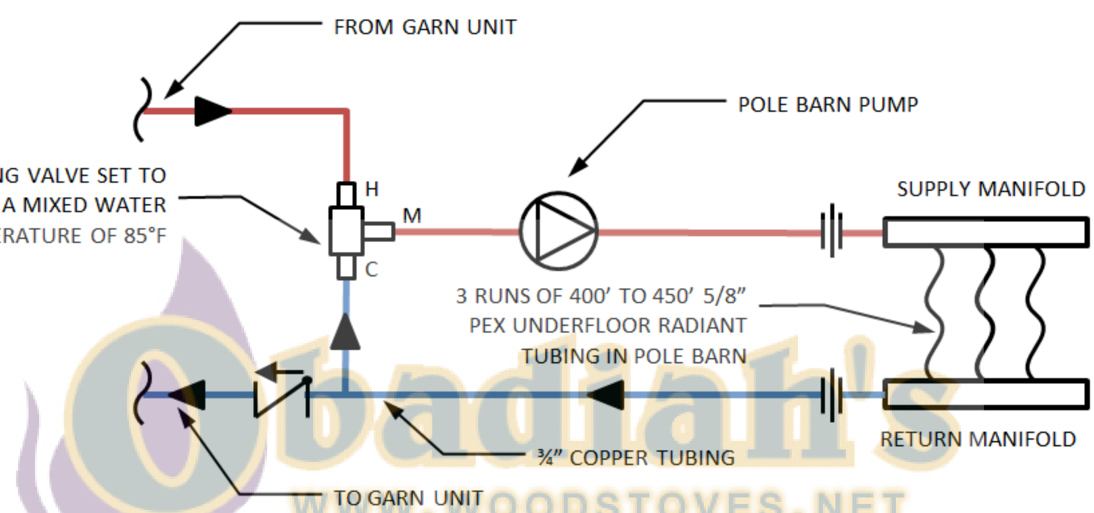


Figure 2: Pole Barn Schematic

SIZE POLE BARN PUMP

400' of 5/8" PEX @ 1.20 gpm	$400'\left(\frac{1.8'}{100'}\right) = 7.2'$
Manifold	2'
20' of ¾" Type L Copper	$20'\left(\frac{4'}{100'}\right) = 1'$
Mixing Valve	3.6'
12' of 2" Steel Pipe @ 12.5 gpm	$12'\left(\frac{0.4'}{100'}\right) = 0.05'$
Subtotal	14'
Misc Fittings	10%
Total Head Loss	15.4'

Size the house pump for 3.4 gpm @ 15.4'

Choose a Taco **0015** 3-speed pump with pump control center and room thermostat. Set pump to speed 2. For more information see:

[TACO® HVAC 0015 Circulator](#)
[TACO® 0015 Performance Curve](#)

Because the pole barn piping is 85°F water, there is no need to check the Net Positive Suction Head.

Reference the following figure for the GARN® side system schematic:

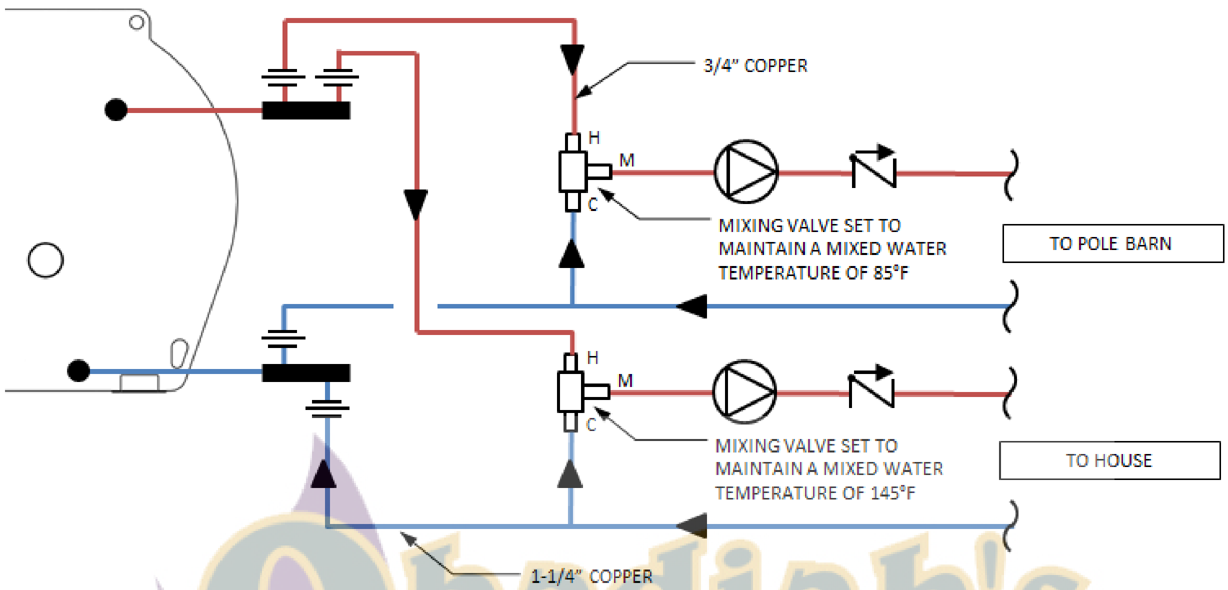


Figure 3: GARN® System Schematic

Refer to earlier sections of this design guide for suggested locations of ball valves, dielectric unions, air vents, etc.