MANUAL 2100-078

WATER SYSTEMS
AND
WELL PUMP AND PIPE SIZING
FOR
WATER SOURCE HEAT PUMPS

BARD MANUFACTURING CO. • BRYAN, OHIO 43506

Dependable quality equipment. . .since 1914

WATER SUPPLY

It is important to have water with enough pressure to insure the proper flow for the unit, and purity to prevent scaling which impedes heat transfer and reduces efficiency. Insufficient water, in the heating mode for example, particularly at low water temperatures, will cause the low pressure control to trip, shutting down the heat pump. In assessing the capacity of the water system, it is advisable that the complete water system be evaluated to prevent possible lack of water or water pressure at various household fixtures whenever the heat pump turns on. All plumbing to and from the unit is to be installed in accordance with local plumbing codes. The use of plastic pipe, where permissible, is recommended to prevent electrolytic corrosion of the water pipe. Because of the relatively cold temperatures encountered with well water, it is strongly recommended that the water lines connecting the unit be insulated to prevent water droplets from condensing on the pipe surface.

Bard high efficiency water source heat pumps are designed to be used with ground water in the temperature ranges of 45°F - 75°F. We do not recommend the use of ponds for supply water and have very heavily discouraged people from this type of application due to the severe and large amount of problems encountered. This unit is <u>not</u> designed to be used on lakes, ponds or rivers because in areas where they freeze over, these water temperatures drop to 38°F, which is too cold for the proper operation.

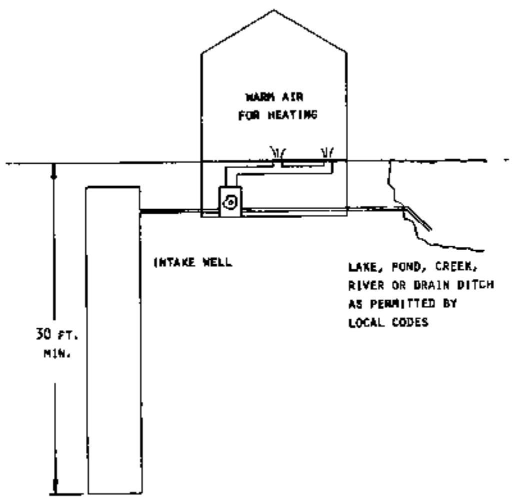
Besides becoming too cold for proper operation of units, the few people who have tried ponds have had considerable problems with dirt, silt, fish, etc., and found it very, very hard to filter.

We recommend the use of lakes, ponds and rivers for disposal of water only.

People have also tried closed loop systems whereby they inserted a long plastic piping system under water to use as a heat sink source. They ran into problems after a period of time with algae and growth on the outside of the plastic piping and losing thermal conductivity. They also encountered problems with anchors from fishing boats pulling up and breaking the plastic pipes.

WATER DISPOSAL METHODS

DISCHARGE TO LAKE OR POND



ADVANTAGES OF LAKE OR POND DISPOSAL

1. Simplicity
2. Low first cost
3. Easy maintenance

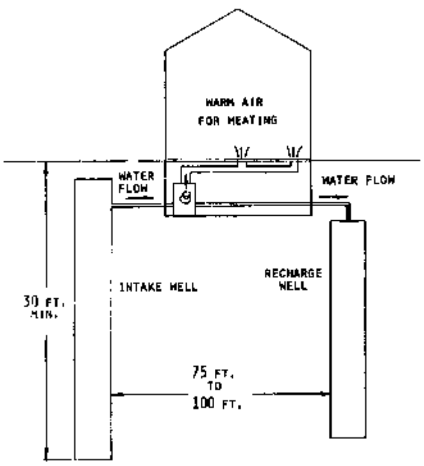
DISADVANTAGES

1. Pond may flood
2. Aquifer may deplete
3. May require large surface area

RECOMMENDATIONS

1. Check soil permeability

TWO WELL INSTALLATION



ADVANTAGES OF RETURN WELL

1. Tidiest method
2. Includes most installations

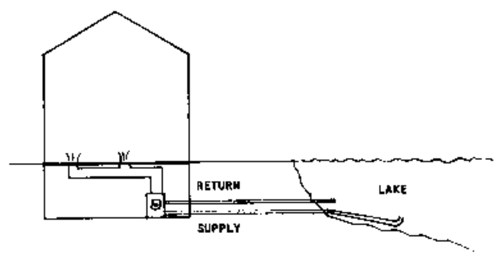
DISADVANTAGES

1. High first cost
2. Subject to clogging
3. Environmentally potential problem
4. Thermal interference between wells

RECOMMENDATIONS

1. Oversize return well
2. Keep pipe pressure loss to a minimum - both wells
3. Space wells adequately - minimum 50 feet
4. Consult a qualified well driller

LAKE AS SUPPLY AND HEAT SINK



NOT RECOMMENDED BY BARD

ADVANTAGES

1. Low cost

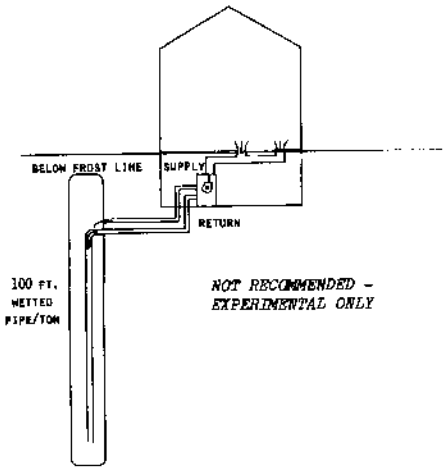
DISADVANTAGES

1. <u>Water must be minimum 45°</u> supplying the unit for heating.
2. <u>Water must be 85° maximum</u> supplying the unit for cooling.
3. Site selective
4. Thermal interference
5. Subject to plugging

RECOMMENDATIONS

1. Screen over intake and discharge
2. Spacing between intake and discharge
3. At least 5 acres for a 3-ton unit
4. Average depth 18 feet or more
5. Intake below 15 foot level

GROUND OR SINGLE WELL
CLOSED LOOP INSTALLATION



WELL PUMP AND PIPE SIZING (Water System Worksheet)*

Strictly speaking, sizing the well pump is the responsibility of the well drilling contractor. It is important, however, that the HVAC contractor be familiar with the factors that determine what size pump will be required. Rule of thumb estimates will invariably lead to under or oversized well pumps. Undersizing the pump will result in inadequate water to the whole plumbing system but with especially bad results to the heat pump--NO HEAT/NO COOL calls will result. Oversized pumps will short cycle and could cause premature pump motor or switch failure.

The well pump must be capable of supplying enough water and at an adequate pressure to meet competing demands of water fixtures. The well pump must be sized in such a way that three requirements are met:

1. Adequate flow rate in gpm.
2. Adequate pressure at the fixtures.
3. Able to meet the above from the depth of the well-feet of lift.

The pressure requirements put on the pump are directly affected by the diameter of pipe being used as well as by the water flow rate through the pipe. The worksheet included in these instructions should guarantee that the well pump has enough capacity. It should also ensure that the piping is not undersized which would create too much pressure due to friction loss. High pressure losses due to undersized pipe will reduce efficiency and require larger pumps and could also create water noise problems.

The worksheet assumes a residence having a submersible pump and three branches in the water system, (1) well pump to the pressure tank branch, (2) the household plumbing branch, and (3) the water source heat pump branch. If your installation requires more branches (and therefore more peak demand for water flow), these additional branches must be included in the calculations for sizing the well pump.

Most household water systems will require 30 psig pressure to work dishwashers, clotheswashers, etc. It is reasonable to assume a 30 psig pressure requirement for the household and avoid pipe sizing calculations for an entire household plumbing system.

Most well systems include a pressure storage tank connected to the well pump. The purpose of this tank is to maintain adequate pressure for the plumbing while avoiding turning on the well pump every time a small amount of water is required.

Hydropneumatic water storage tanks should not be used. These tanks are partially filled with air which is compressed as the water is pumped into the tank. Thus, the compressed air maintains a constant pressure on the water. However, air under pressure will dissolve into the water requiring more and more water to maintain pressure. Additionally, the air and water mixture can be somewhat more corrosive.

Instead, diaphragm or bladder type pressure tanks must be installed. This type of tank separates the water from the air with a heavy rubber diaphragm inside the metal tank and prevents the water and compressed air from mixing.

The pressure tank setting of the water storage tank should be selected to provide adequate pressure for that branch of the water system having the highest pressure requirement. This could be the household plumbing branch or the heat pump branch.

TABLE 8.4

Water Uses	Peak Demand Allowance for Pump gpm Column 1	Individual Fixture Flow Rate gpm Column 2
Household Uses		
Bathtub or tub-and-shower combination	2.00	8.0
Shower only	1.00	4.0
Lavatory	.50	2.0
Toilet—flush tank	.75	3.0
Sink, kitchen—including garbage disposal	1.00	4.0
Diswasher	.50	2.0
Laundry Sink	1.50	6.0
Clothes Washer	2.00	8.0
Irrigation, Cleaning and Miscellaneous		
Lawn irrigation (per sprinkler)	2.50	5.0
Garden irrigation (per sprinkler)	2.50	5.0
Automobile washing	2.50	5.0
Tractor and equipment washing	2.50	5.0
Flushing driveways and walkways	5.00	10.0
Cleaning milking equipment & milk storage tank	4.00	8.0
Hose cleaning barn floors, ramps, etc.	5.00	10.0
Swimming pool (initial filling)	2.50	5.0

TABLE 8.8

FRICTION LOSSES THROUGH FITTINGS
IN TERMS OF EQUIVALENT LENGTHS OF PIPE

Type Fitting & Application	Pipe & Ftg. Material (Note 1)	Equivalent Length of Pipe Nominal Size Fitting & Pipe 1/2	3/4	1	1¼	1½	2	2½
Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter Plastic or Copper to Thread	Copper	1	1	1	1	1	1	1
	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	3	3	4	4	5	6
	Copper	2	3	3	4	4	5	6
	Plastic	4	5	6	7	8	9	10
Standard Tee Flow Thru Run	Steel	1	2	2	3	3	4	5
	Copper	1	2	2	3	3	4	5
	Plastic	4	4	4	5	6	7	8
Standard Tee Flow Thru Side	Steel	4	5	6	8	9	11	14
	Copper	4	5	6	8	9	11	14
	Plastic	7	8	9	12	13	17	20
Gate Valve	Note (2)	2	3	4	5	6	7	8
Swing Check Valve	Note (2)	4	5	7	9	11	13	16

Friction loss tables for fittings (Table 8.8). Figures given are friction losses in terms of equivalent length (in feet) of straight pipe. Note: (1) Loss figures are based on equivalent lengths of indicated pipe material and (2) Loss figures are for screwed valves and are based on equivalent lengths of steel pipe.

*Water System Worksheet Form 1001-1081)

GPM	1/2" ID = .622"				3/4" ID = .824"				1" ID = 1.049"			
	Steel		Plastic		Steel		Plastic		Steel		Plastic	
	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs
2	4.8	2.1	4.1	1.8								
3	10.0	4.3	8.7	3.8	2.5	1.1	2.2	1.0				
4	17.1	7.4	14.8	6.4	4.2	1.8	3.7	1.6				
5	25.8	11.2	22.2	9.6	6.3	2.7	5.7	2.5	1.9	.8	1.8	.8
6	36.5	15.8	31.2	13.5	8.9	3.9	8.0	3.5	2.7	1.2	2.5	1.1
7	48.7	21.1	41.5	18.0	11.8	5.1	10.6	4.6	3.6	1.6	3.3	1.4
8	62.7	27.2	53.0	23.0	15.0	6.5	13.5	5.9	4.5	2.0	4.2	1.8
9	78.3	34.0	66.0	28.6	18.8	8.2	16.8	7.3	5.7	2.5	5.2	2.3
10	95.9	41.6	80.5	34.9	23.0	10.0	20.4	8.9	6.9	3.0	6.3	2.7
12					32.6	14.1	28.6	12.4	9.6	4.2	8.9	3.9
14					43.5	18.9	38.0	16.5	12.8	5.6	11.8	5.1
16					56.3	24.4	48.6	21.1	16.5	7.2	15.1	6.6
18					70.3	30.5	60.5	26.3	20.6	8.9	18.7	8.1
20					86.1	37.4	73.5	31.9	25.1	10.9	22.8	9.9
22					104.0	45.1			30.2	13.1	27.1	11.8
24									35.6	15.5	31.1	13.5
25									38.7	16.8	34.6	15.0
30									54.6	23.7	48.1	20.9
35									73.3	31.8	64.3	27.9
40									95.0	41.2	82.0	35.6

Areas above the heavy lines are recommended for normal operation.

TABLE 8.6

Friction loss Tables 8.6 and 8.7 for common pipe diameters and materials. Figures given are friction loss in feet of head per one hundred feet of pipe. Doubling the diameter of a pipe increases its capacity four times, not two times.

GPM	1¼" ID - 1.380"				1½" ID = 1.610"				2" ID - 2.067"			
	Steel		Plastic		Steel		Plastic		Steel		Plastic	
	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs	Ft	Lbs
10	1.8	.8	1.7	.7								
12	2.5	1.1	2.3	1.0	1.2	.5	1.1	.5				
14	3.3	1.4	3.1	1.3	1.5	.7	1.4	.6				
16	4.2	1.8	4.0	1.7	2.0	.9	1.9	.8				
18	5.2	2.3	4.9	2.1	2.4	1.1	2.3	1.0				
20	6.3	2.7	6.0	2.6	2.9	1.3	2.8	1.2				
25	9.6	4.2	9.1	3.9	4.5	2.0	4.3	1.9	1.3	.6	1.3	.6
30	13.6	5.9	12.7	5.5	6.3	2.7	6.0	2.6	1.8	.8	1.8	.8
35	18.2	7.9	16.9	7.3	8.4	3.6	8.0	3.5	2.4	1.0	2.4	1.0
40	23.5	10.2	21.6	9.4	10.8	4.7	10.2	4.4	3.1	1.3	3.0	1.3
45	29.4	12.8	28.0	12.2	13.5	5.9	12.5	5.4	3.9	1.7	3.8	1.6
50	36.0	15.6	32.6	14.1	16.4	7.1	15.4	6.7	4.7	2.0	4.6	2.0
60	51.0	22.1	45.6	19.8	23.2	10.1	21.6	9.4	6.6	2.9	6.4	2.8
70	68.8	29.9	61.5	26.7	31.3	13.6	28.7	12.5	8.9	3.9	8.5	3.7
80	89.2	38.7	77.9	33.8	40.5	17.6	36.8	16.0	11.4	5.0	10.9	4.7
90	112.0	48.6	96.6	41.9	51.0	22.1	45.7	19.8	14.2	6.2	13.6	5.9
100	138.0	59.9			62.2	27.0	56.6	24.6	17.4	7.6	16.5	7.2
120					88.3	38.3			24.7	10.7	23.1	10.0
140					119.0	51.6			33.2	14.4	30.6	13.2
160					156.0	67.7			43.0	18.7	39.3	17.1
180									54.1	23.5	48.9	21.2
200									66.3	28.8	59.4	25.8
220									80.0	34.7		
240									95.0	41.2		
260									111.0	48.2		

Areas above the heavy lines are recommended for normal operation.

TABLE 8.7

TABLE 8.10						
MINIMUM WATER REGULATING VALVE PRESSURE DROP						
	1/2"		3/4"		1"	
GPM	Psi	Ft.Hd.	Psi	Ft.Hd.	Psi	Ft.Hd.
4	4	9.2	1	2.3	-	-
5	6	13.9	1.3	3.0	-	-
10.6	9.5	22.0	3	6.9	1.5	3.5
12.7	15	34.6	4.2	9.7	2	4.6

TABLE 8.12*	
TOTAL VOLUME AND ACCEPTANCE VOLUME	
Nominal Tank Size (Total Vol.Gals)	Maximum (Acceptance Volume)
2.0	0.9
4.4	2.4
8.6	3.2
14.0	11.3
20.0	11.3
32.0	11.3
44.0	34.0
62.0	34.0
86.0	34.0

*Or use tables for specific pressure tank being used for water system.

WATER CORROSION

Two concerns will immediately come to light when considering a water source heat pump, whether for ground water or for a closed loop application: Will there be enough water? And, how will the water quality affect the system?

Water quantity is an important consideration and one which is easily determined. The well driller must perform a pump down test on the well according to *methods described by the National Well Water Association.* This test, if performed correctly, will provide information on the rate of flow and on the capacity of the well. It is important to consider the overall capacity of the well when thinking about a water source heat pump because the heat pump may be required to run for extended periods of time.

The second concern, about water quality, is equally important. Generally speaking, if the water is not offensive for drinking purposes, it should pose no problem for the heat pump. The well driller or local water softening company can perform tests which will determine the chemical properties of the well water.

Water quality problems will show up in the heat pump in one or more of the following ways:

1. Increased water flow to the unit.
2. Decreased heat transfer of the water coil (entering to leaving water temperature difference is less).

There are four main water quality problems associated with ground water. These are:

(1) Biological growth. This is the growth of microscopic organisms in the water and will show up as a slimy deposit throughout the water system. Shock treatment of the well is usually required and this is best left up to the well driller. The treatment consists of injecting chlorine into the well casing and flushing the system until all growth is removed.

(2) Suspended particles in the water. Filtering will usually remove most suspended particles (fine sand, small gravel) from the water. The problem with suspended particles in the water is that it will erode metal parts, pumps, heat transfer coils, etc. So long as the filter is cleaned and periodically maintained, suspended particles should pose no serious problem. Consult with your well driller.

(3) Corrosion of metal. Corrosion of metal parts results from either highly corrosive water (acid water, generally not the case with ground water) or galvanic reaction between dissimilar metals in the presence of water. By using plastic plumbing or di-electric unions galvanic reaction is eliminated. The use of corrosion resistant materials (such as the Cupro nickel coil) throughout the water system will reduce corrosion problems significantly.

TABLE 8.11 - PRESSURE FACTORS*

PUMP CUT-OUT PRESSURE – PSIG	PUMP CUT-IN PRESSURE – PSIG														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
30	.22														
35	.30	.20													
40	.37	.27	.18												
45	.42	.34	.26	.17											
50	.46	.39	.31	.23	.15										
55	.50	.43	.36	.29	.22	.14									
60	.54	.47	.40	.33	.27	.20	.13								
65		.50	.44	.38	.31	.25	.19	.13							
70		.53	.47	.41	.35	.30	.24	.18	.12						
75			.50	.45	.39	.33	.28	.22	.17	.11					
80			.53	.48.	.42	.37	.32	.26	.21	.16	.11				
85				.50	.45	.40	.35	.30	.25	.20	.15	.10			
90				.53	.48	.43	.38	.33	.29	.24	.19	.14	.10		
95					.50	.46	.41	.36	.32	.27	.23	.18	.14	.09	
100					.52	.48	.44	.39	.35	.31	.26	.22	.17	.13	.09

(4) Scale formation. Of all the water problems, the formation of scale by ground water is by far the most common. Usually this scale is due to the formation of calcium carbonate but magnesium carbonate or calcium sulfate may also be present. Carbon dioxide gas (CO_2), the carbonate of calcium and magnesium carbonate, is very soluble in water. It will remain dissolved in the water until some outside factor upsets the balance. This outside influence may be a large change in water temperature or pressure. When this happens, enough carbon dioxide gas combines with dissolved calcium or magnesium in the water and falls out of solution until a new balance is reached. The change in temperature that this heat pump produces is usually not high enough to cause the dissolved gas to fall out of solution. Likewise if pressure drops are kept to a reasonable level, no precipitation of carbon dioxide should occur.

REMEDIES OF WATER PROBLEMS

WATER TREATMENT. Water treatment can usually be economically justified for closed loop systems. However, because of the large amounts of water involved with a ground water heat pump, water treatment is generally too expensive.

ACID CLEANING THE WATER COIL OR HEAT RECOVERY UNIT.

If scaling of the coil is strongly suspected, the coil can be cleaned up with a solution of Phosphoric Acid (food grade acid)
Follow the manufacturer's directions for mixing, use, etc. Refer to the, Cleaning Water Coil, Figure24). The acid solution can be introduced into the heat pump coil through the hose bib (Part 8 of Figure 24). Be sure the isolation valves (Parts 9 and 11 of Figure 24) are closed to prevent contamination of the rest of the system by the coil. The acid should be pumped from a bucket into the hose bib (Part 8, Figure 24) and returned to the bucket through the other hose bib (Part 10, Figure 24). Follow the manufacturer's directions for the product used as to how long the solution is to be circulated, but it is usually circulated for a period of several hours.

UNDER NO CIRCUMSTANCES SHOULD THE HEAT PUMP BE OPERATED IN SUCH A WAY AS TO FREEZE THE COIL IN AN ATTEMPT TO BREAK SCALE FREE.

While no damage is expected to be done to the coil from freezing, undue strain is put on the refrigeration system and this practice should not be attempted.

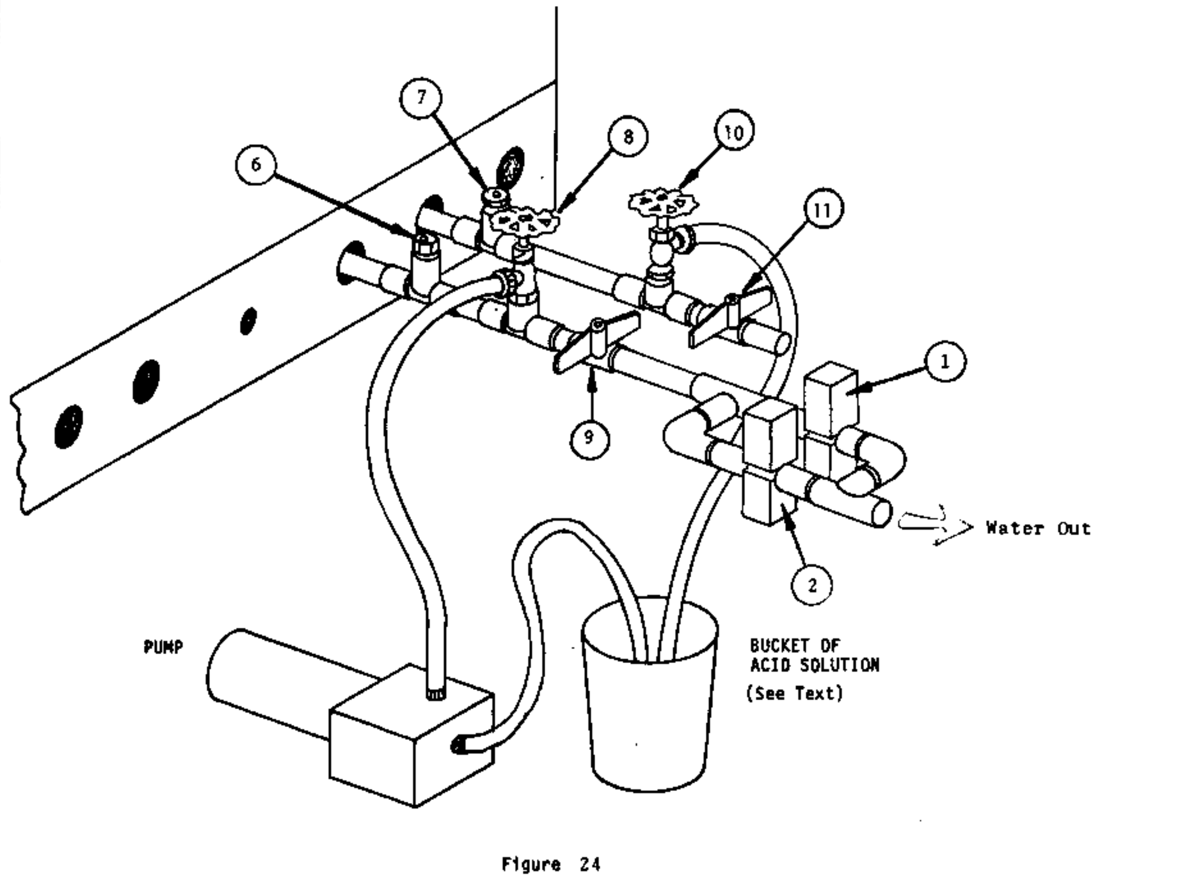


Figure 24

WATER SYSTEM WORKSHEET

(METHOD APPLICABLE TO SUBMERSIBLE PUMPS. CONSULT WELL DRILLER FOR SIZING OF OTHER TYPES OF PUMPS)

A. WELL PUMP SIZING

Branch "A" - Well Pump	-	Piping from pump in well to pressure tank.
Branch "B" - Domestic Water Supply	-	Piping from tank to the fixtures throughout house.
Branch "C" - Heat Pump Water Supply	-	Piping from tank through heat pump coil to drain.

1. Determine household water needs from Table 8.4, Column 1. Enter here. ________gpm Branch B

2. Enter gpm flow rate for unit to be installed from specifications (water coil rated flow). ________gpm Branch C

3. Add lines 1 and 2 for total water flow rate required. ________gpm Branch A

NOTE: IF PIPING LAYOUT HAS MORE BRANCHES, DETERMINE THE FLOW RATE FOR THESE FROM TABLE 8.4, COLUMN 1, AND INCLUDE IN TOTAL.

B. DETERMINING WATER PRESSURE REQUIREMENTS PIPE SIZING FOR EACH PIPE BRANCH—Household plumbing, Branch B, may be assumed to have a total pressure requirement of 30 psig.

		Branch A	Branch C	
4.	Tentatively select a pipe size and enter here. Table 8.6 or 8.7.			inch pipe
5.	Consult Table 8.8 and enter equivalent feet of pipe for one elbow of the size selected in step 4 above using gpm of the branch. Enter here.			equiv. feet
6.	From the piping layout, determine the number of elbows needed for the branch. Enter here.			elbows
7.	Multiply line 5 by line 6. Enter total here.			equiv. feet
8.	From piping layout, determine total lineal feet of pipe in the branch. Enter here.			lineal feet
9.	Add lines 7 and 8. Enter here.			total feet
10.	Consult Table 8.6 and 8.7 for total feet (line 9) and total gpm needed (for each branch determined from Section A above) and enter friction loss here.			ft.hd/100 ft.
11.	Multiply line 10 by line 9, divide by 100 and enter here as total piping friction loss.			ft. hd.
12.	Multiply line 11 by 0.433 to convert to psig. Enter here.			psig
13.	Consult manual for the unit to be installed and enter unit pressure drop here. Branch C only. (Water coil pressure drop)			psig unit
14.	Consult Table 8.10 for the pressure drop of the water regulating valve using the appropriate size and flow rate (line 2). Branch C.			psig regulating valves
15.	Calculate total pressure drop, Branch C, by adding lines 12, 13 and 14. Enter here. Branch A pressure drop is the same as line 12 Branch A and should be entered here.			psig

16. From the piping layout, determine parallel flow among the branches. Beginning at the well pump, add the friction loss in psig for the well pump branch (Branch A) to the branch having the higher pressure drop (Branch B or Branch C). Note: If more than three branches are required by the piping layout, select that branch which has the highest pressure drop and add this pressure drop to Branch A. Enter in line 16 the number obtained as total piping pressure loss due to pipe friction. ________psig

17. To the branch having the higher pressure drop (Branch B or C used in line 16), add 20 psig to obtain the pressure switch cut out point. Enter this value here. ________psig Tank cut-out setting

18. Pump requirements will be: ________gpm (line 3) at ________psig (line 17)

at ________feet lift (Vertical distance to water in the well)

REFER TO PUMP MANUFACTURER'S TABLE TO ACTUALLY SELECT THE PUMP MODEL BASED ON REQUIREMENTS ENTERED IN LINE 18.

FORM 1001-1081

-OVER-

C. WATER TANK SIZING (Applicable to bladder or diaphragm type tanks only - recommended type).

19. Enter desired minimum off time of the well pump in minutes and fractions of minutes. Never less than two minutes. ________________ minutes

20. Enter pressure switch cut-in point psig. At least as great a pressure as required for Branch B or C. ________________ psig

21. Enter pressure cut-out point psig. Usually 20 psig higher than value in line 20. ________________ psig

CALCULATE TANK SIZE

22. Multiply line 3 by line 19 to determine minimum acceptance volume. ________________ gals.

23. Refer to Table 8.11. Find the tank pressure factor for lines 20 and 21. ________________ P.F.

24. Divide line 22 by line 23 and enter the minimum total tank volume corrected for pressure. ________________ gals.

25. Refer to Table 8.12 and select a tank model that is greater than line 24 for "Total Volume" and equal to or greater than line 22 for "Acceptance Volume." (Refer to water tank manufacturer's specifications).