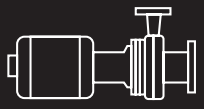
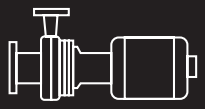
ENERGY RETROFIT PROGRAM

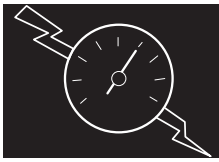
An innovative but simple retrofit for existing hot water and chilled water piping systems that will help you save money.

REDUCE FLOW BY 50%

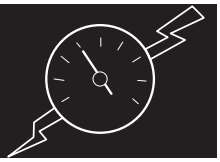


REDUCE PUMP HEAD BY 75%





REDUCE PUMP POWER USE BY 87%



- Eliminate costly maintenance problems such as blocked terminal units, corrosion, pump cavitation, improper balancing, and puzzling pump performance.
- Eliminate costly chemical treatment.
- Guarantee desired hydraulic performance.

Operate Your System with 87% Less Pump Power, 99% of the Year

Most existing systems use constant flow at full load velocity.

Your present system is probably operating at a constant flow rate, independent of heat requirements. Heat is controlled by the outdoor reset of boiler water temperature, or by modulated water temperature with three-way valves. So, no matter what your actual heat requirement is, your pump(s) is constantly operating at design load flows. This is because designers have learned that systems have fewer problems when flow is kept high and constant.

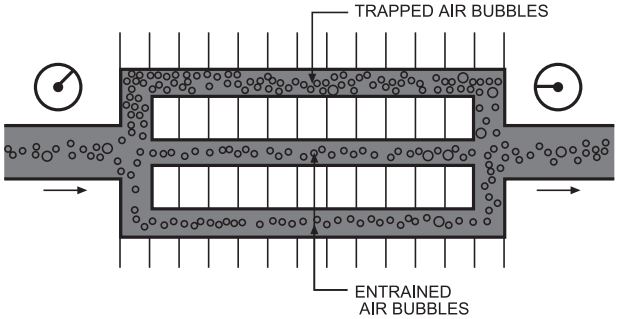
CORROSION CAN OCCUR
WHEN AIR IS TRAPPED

Constant flow is required for systems in which air exists.

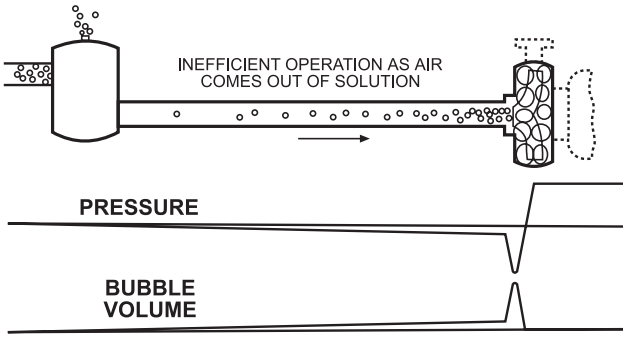
System air, or air bubbles in system piping, can cause many problems such as corrosion, blockage of terminal units, improper system balance and pump cavitation. In most existing systems, air bubbles are purged through terminal units by constant high velocity. If flow were reduced, air bubbles would collect in terminal units causing loss of heat transfer, corrosion and other problems.

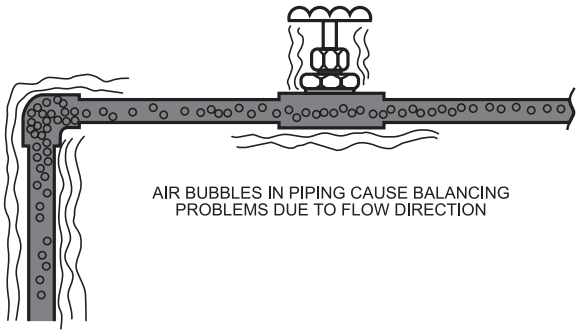
High pump heads also have been used to ensure enough positive pressure to keep air in solution or keep air bubbles small.

In the typical HVAC system, constant volume pumping at full design load is used to prevent control and distribution problems, primarily due to the presence of air in the system.

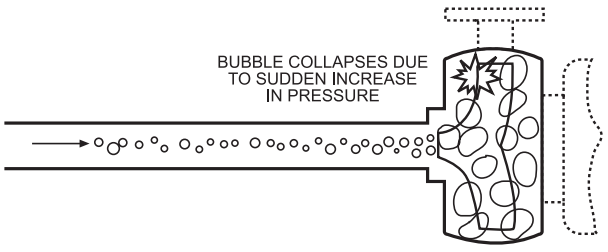


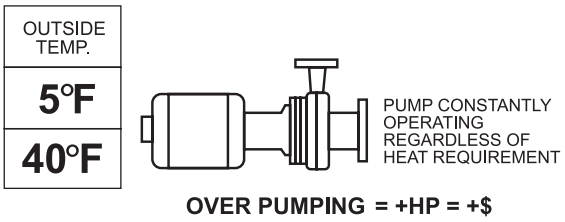
AIR BINDING OF TERMINAL UNITS OCCURS
AT LOW FOW RATES





AIR BUBBLES IN PIPING CAUSE BALANCING
PROBLEMS DUE TO FLOW DIRECTION





OVER PUMPING = +HP = +$

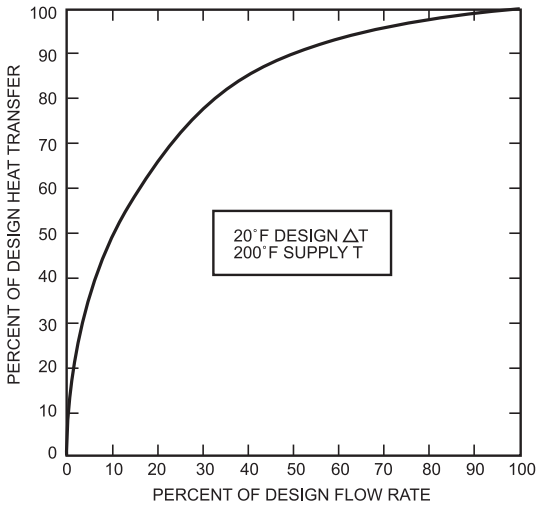


Figure 1. Effect of flow variation on heat transfer for typical terminal unit.

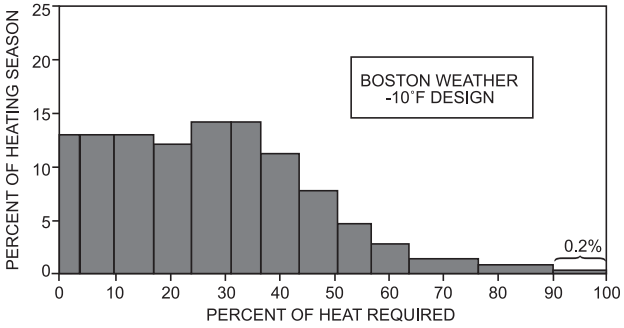


Figure 2. Calculated distribution of heat requirement as a percentage of heating season.

Constant pumping at high flow rates requires high pump power.

Your system was designed for an anticipated coldest day of the year. A pump was probably selected to deliver a constant flow rate to terminal units for design output at this level of outdoor temperature.

Because constant pumping is used to purge air, the large pump or pumps will run at this high flow rate during the heating season regardless of outdoor temperature. This over pumping consumes a maximum amount of horsepower or electrical energy that is not dictated by the varying heat load.

Terminal units do not require constant flow to deliver adequate heat.

Terminal units in your system also have been designed for the coldest day of the year, but they do not require constant flow to meet varying heating demands.

Figure 1 shows the result of reducing flow through a typical terminal unit. For example, reducing flow by 50% results in only a 10% reduction of heat output.

Your system rarely operates at outdoor design temperatures.

Your system was designed for adequate heating on extremely cold days, especially if it is more than 4 years old. During the actual heating season, however, outdoor temperatures are mostly substantially above this design temperature.

Figure 2 shows the calculated distribution of heat requirements for one season in the Boston Metropolitan area with a system design temperature of -10°F. In this specific case, with a heating season of 6,417 hours, it can be seen that full output of heat from terminal units is only required for 12 hours. The rest of the season (6,405 hours) the system will provide adequate heat with thermal units at 90% output and flow through the terminal units at 50% of full load requirements.

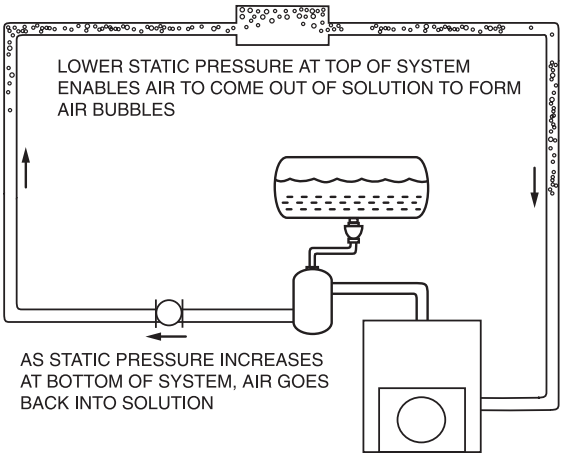
Plain Steel Expansion Tanks Are A Major Source of Air Bubbles

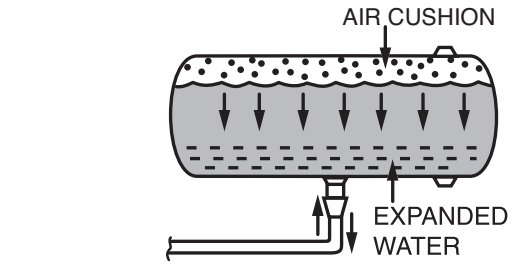
It can be demonstrated conclusively that the major source of air in an existing piping system comes from the plain steel expansion tank(s) used to pressurize the system and accommodate expanded water during the operating cycles of the system. Air in the calculated air cushion of the tank is absorbed by system water during the operating pressure range of the system. Since the tank is installed at the bottom of the system, static height keeps pressure high in the tank. According to known laws of solubility, the rate of air absorption in the air cushion of the tank is high and constant.

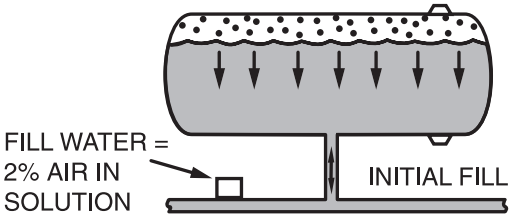
Air in solution leaves the tank with system water during the operating cycle. It is carried by system piping to the top of the system where it loses static pressure. At this lower pressure range, air in solution is released to form free and entrained air bubbles. If flow rates were lowered, these bubbles would collect and cause system malfunction.

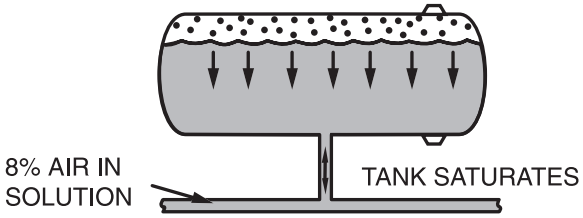
Since these bubbles represent a portion of the required air cushion calculated to pressurize and maintain proper pressure control that was originally in the steel tank, they cannot be vented in the parameters of air control.

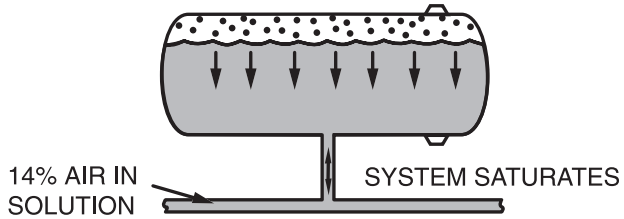
Once vented, the required air cushion would be dramatically reduced and the system would no longer operate under original pressure designs.

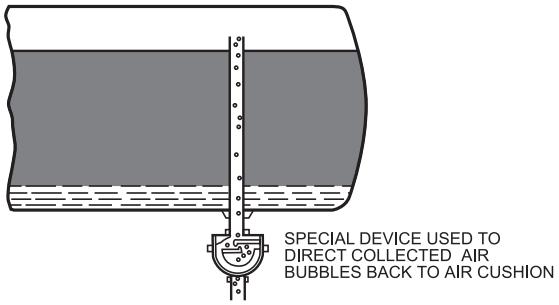


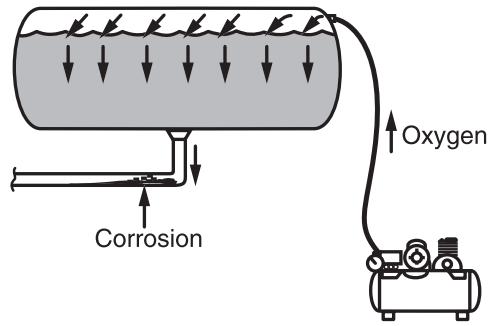












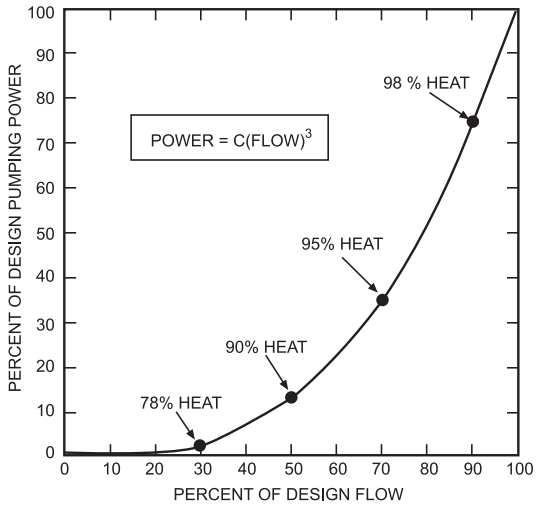


Figure 3. Effect of flow variation on required pumping power and percent heat transfer available.

Under the air control philosophy, high head pumping and high velocity flow rates are used to purge these air bubbles through the piping, terminal units and valves – back to the expansion tank location where an attempt is made to separate and redirect them back to the tank's air cushion where they belong.

However, as the bubbles flow with system water down through the piping, static pressure increases, and they go back into solution. In this state, air cannot be separated and it passes completely through the separation stage. Once air reaches the upper levels of the system, it once again comes out of solution because of lower pressure.

Replenishing the air cushion in the tank with an air compressor only adds to the problem as more and more air is pumped into the system piping causing more and more air bubbles and their associated problems.

The only answer is to utilize over pumping to force air bubbles through the piping and terminal units and through high pump heads, keeping positive pressure on system piping in an attempt to keep air in solution or reduce the size of the bubbles.

Air elimination allows low flow and reduced pumping power during most of the heating season.

Since tradition and experience has proven that high pump heads and velocity are required for air control rather than heat transfer, eliminating all air from the system piping will eliminate all problems associated with air. Pump heads and flow can then be reduced to meet varying heat demands without over pumping to provide air control. Figure 3 shows the effect of flow variation on required pumping power and percent heat transfer available.

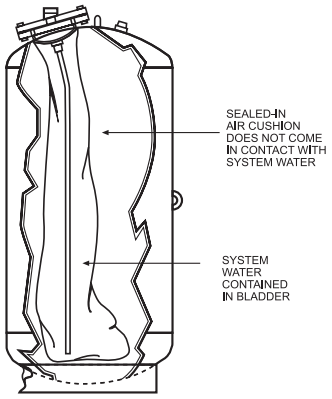
How the Program Works in Your System to Save Energy and Solve Maintenance Problems

The first step is the air elimination system.

Instituting the retrofit requires the addition of an air elimination system applied to your system piping.

The application consists of a diaphragm or bladder type expansion tank.

Located in your equipment room, it has the necessary air cushion for pressurization and pressure control. This air cushion never interfaces directly with system water and never can be dissolved or absorbed by system water. With the proper air cushion permanently sealed-in there is no longer a need for air control.

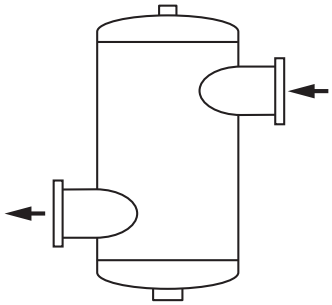


BLADDER-TYPE EXPANSION TANK

An air elimination separator/eliminator.

Now all other air in system piping can be completely eliminated so there will no longer be a need to purge air bubbles with high head, high velocity pumping. This elimination of air is accomplished with a small air separator and a pilot-operated air elimination valve located at the top of the system on vertical risers before system water enters horizontal runs.

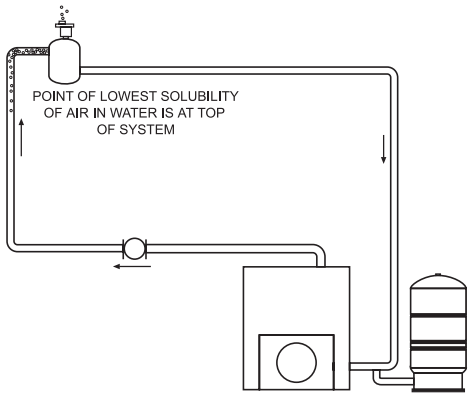
At this point, selected by solubility tables, pressures are lowest, and all air will come out of solution. The separator supplied will separate 94% of all air bubbles on the first pass through its interior. The air elimination valve will instantly eliminate as much air as the separators. Water leaving this separation / elimination point will be completely free of air bubbles.



TANGENTIAL TYPE
AIR SEPARATOR

Once air is eliminated, you can reduce pumping power.

Since you no longer need to purge air bubbles, you can substantially reduce pumping power by using a much smaller pump in parallel with your existing large pump, to handle heat transfer demands throughout most of the heating season.



SOLUBILITY OF AIR IN WATER

RATIO OF ABSORBED AIR VOLUME TO WATER VOLUME
EXPRESSED AS A DECIMAL

TEMP. (t) °F	PRESSURE, PSIG												
	0	10	20	30	40	50	60	70	80	90	100	110	120
40°	0.0258	0.0435	0.0613	0.0790	0.0967	0.1144	0.1321	0.1499	0.1676	0.1853	0.2030	0.2207	0.2384
50°	0.0223	0.0376	0.0529	0.0683	0.0836	0.0989	0.1143	0.1296	0.1449	0.1603	0.1756	0.1909	0.2063
60°	0.0197	0.0333	0.0469	0.0505	0.0742	0.0878	0.1017	0.1150	0.1296	0.1423	0.1559	0.1695	0.1831
70°	0.0177	0.0300	0.0423	0.0546	0.0669	0.0792	0.0916	0.1039	0.1162	0.1285	0.1408	0.1531	0.1654
80°	0.0161	0.0274	0.0387	0.0501	0.0614	0.0727	0.0840	0.0954	0.1067	0.1180	0.1293	0.1407	0.1520
90°	0.0147	0.0253	0.0358	0.0464	0.0569	0.0674	0.0750	0.0885	0.0990	0.1090	0.1201	0.1306	0.1412
100°	0.0136	0.0235	0.0334	0.0433	0.0532	0.0631	0.0730	0.0829	0.0928	0.1027	0.1126	0.1225	0.1324
110°	0.0126	0.0220	0.0314	0.0408	0.0501	0.0595	0.0689	0.0753	0.0877	0.0971	0.1065	0.1158	0.1252
120°	0.0117	0.0206	0.0296	0.0385	0.0475	0.0564	0.0654	0.0744	0.0833	0.0923	0.1012	0.1102	0.1191
130°	0.0107	0.0193	0.0280	0.0366	0.0452	0.0538	0.0624	0.0710	0.0796	0.0882	0.0968	0.1054	0.1140
140°	0.0098	0.0182	0.0265	0.0348	0.0432	0.0515	0.0598	0.0681	0.0765	0.0848	0.0931	0.1015	0.1098
150°	0.0089	0.0170	0.0251	0.0332	0.0413	0.0494	0.0574	0.0655	0.0736	0.0817	0.0898	0.0979	0.1060
160°	0.0079	0.0158	0.0237	0.0316	0.0395	0.0474	0.0553	0.0632	0.0711	0.0790	0.0869	0.0945	0.1027
170°	0.0068	0.0145	0.0223	0.0301	0.0378	0.0456	0.0534	0.0611	0.0689	0.0767	0.0844	0.0922	0.1000
180°	0.0055	0.0132	0.0208	0.0285	0.0361	0.0438	0.0514	0.0591	0.0667	0.0744	0.0820	0.0879	0.0973
190°	0.0041	0.0116	0.0192	0.0268	0.0344	0.0420	0.0496	0.0571	0.0647	0.0723	0.0799	0.0875	0.0950
200°	0.0024	0.0099	0.0175	0.0250	0.0326	0.0401	0.0477	0.0552	0.0628	0.0703	0.0779	0.0854	0.0930
210°	0.0004	0.0080	0.0155	0.0230	0.0306	0.0381	0.0457	0.0532	0.0607	0.0683	0.0758	0.0833	0.0909

Based on derivation by Professor Ferdinand Votta, Jr.,
Department of Chemical Engineering, University of Rhode Island.

HVAC System Evaluation Form

Use this work sheet to evaluate your present system. This evaluation will confirm the presence of system air in your piping system. Air elimination will eliminate costly maintenance problems and reduce energy consumption for pump operation up to 87%.

System Diagram

Make a simple piping sketch showing the relative locations of the existing tank(s), pump(s), relief valves, and hot or chilled water generator. Also note location of pressure gauges from which readings will be taken.

Problem History

A thorough discussion with the operating and maintenance personnel will give a problem history which should fit basic symptoms of system air. The problems listed should be cured by the air elimination retrofit.

- ❑ Binding heating units.
- ❑ Waterlogged tanks.
- ❑ Relief valve opens.
- ❑ Corrosion and leaks.
- ❑ Pumps perform poorly.
- ❑ Pump seal failures.
- ❑ Chemical treatment.
- ❑ Other_____

Pump Test To Confirm Presence of Air

This test will confirm the presence of significant air in the system. While the pump is operating, record the gauge readings. Shut the pump off and again record the gauge readings. The pressure nearest the tank connection will change if there is air in the system. If there is no air, then the pressure will not change. This test can also be used to estimate the severity of the air problem by comparing the change in tank pressure to the head developed by the pump.

Pump Test (For Presence of Air)			
	PSIG		
	Tank	Suction	Discharge
Pump ON			
Pump OFF			

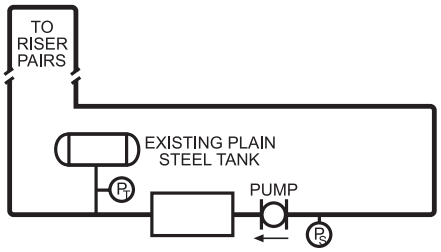
Example

Test made on an actual university building in New England.

Problem History

- ❑ Binding heating units.
- ❑ Waterlogged tanks.
- ❑ Relief valve opens.
- ☑ Corrosion and leaks.
- ☑ Pumps pump poorly.
- ☑ Pump seal failures.
- ☑ Chemical treatment.
- ❑ Other_____

Pump Test (For Presence of Air)			
	PSIG		
	Tank	Suction	Discharge
Pump ON	44	28	
Pump OFF	38	39	



In this installation, a difference of 6 psig at tank gauge between pump on and off, indicates the presence of substantial secondary air in upper system piping. This air is the direct cause of the problems listed.

After air elimination was installed in this building, the tank gauge reading was 30 psig with pump on and off. The listed problems disappeared.

Remember that this test is absolutely reliable. The only way the tank pressure can change is if the amount of water in the tank changes. Since the piping is rigid, the water leaving the tank must be filling space occupied by air. If there is a sight glass on the existing tank, the water level should visibly change when the pump is switched on and off.

Your AMTROL Representative will use this form to select and size the proper air elimination retrofit package.

Energy Use Evaluation*

This form will provide an approximation of your current energy cost to run your existing constant flow HVAC pump(s).

Present Cost

1. Rated H.P. of Pump(s):
   - Pump 1 _____ H.P.
   - Pump 2 _____ H.P.
   - Pump 3 _____ H.P.
2. Total H.P.: _____ H.P.
3. Total kw (line 2 X 1): _____ kw
4. Annual usage (multiply line 3 by seasonal hours shown in table below): _____ kwh
5. Annual Cost (multiply line 4 by your kwh rate): $_____ annual cost.

Anticipated operating cost through Energy Retrofit Program

6. Seasonal hours of system operation in your area (see table below): _____ Hours
7. Hours operation of existing pump(s) (multiply line 6 by 0.1)* _____ Hours
8. Annual kwh of existing pumps (multiply line 7 by line 3): _____ kwh
9. Hours operation of retrofit pump in parallel (line 6 minus line 7): _____ Hours
10. Total kw of retrofit pump (multiply line 3 by 0.2):* _____ kw
11. Annual kwh of retrofit pump(s) (multiply line 9 by line 10): _____ kwh
12. Total annual kwh (line 8 + line 11): _____ kwh
13. Annual cost (line 12 X your kwh rate): $_____
14. Estimated savings through Energy Retrofit Program (line 5 minus line 13): $_____

*This calculation uses conservative estimated pump power reduction factors. Your actual savings could be considerably higher depending upon your system, area and pump size.

Annual seasonal hours of HVAC system operation

(Hours when outdoor temperature is below 62°F)

Source: ASHRAE Handbook, “Systems” Volume 1980 Chapter 43.

Atlanta	4,540	Los Angeles	5,696
Boston	6,417	Minneapolis	6,636
Buffalo	6,579	New York	5,873
Chicago	5,953	Pittsburgh	6,213
Dallas	3,807	St. Louis	5,229
Denver	6,417	San Francisco	7,657
Detroit	6,230	Seattle	7,844

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