Guide to Swimming Pool Heating

YOUR GUIDE TO POOL HEATING OPTIONS AND COSTS

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Guide Updates

Version	Changes Made
7/18/94	Base date of Guide.
5/18/95	Formatting issues on Word 5.1 & Mac Operating System 7.5
1/27/96	Formatting issues on LaserWriter 16/600PS and Driver V8.2
1/30/96	Imported new Therm graph onto page 30. Minor formatting issues.
11/22/00	Converted to Word 98 on Mac Operating System 9.0.4 Converted from Palatino to Times font for standard web documents. Updated Energy Study data on Pages 29-33. Uploaded to web for free non-commercial use and download by pool owners.

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Introduction

This swimming pool heating guidebook is a collection of information helpful to pool owners -- and prospective pool owners -- as they consider ways to heat their swimming pools. There are many types of heating systems available for swimming pools. The way you choose to heat your pool will be based on several factors unique to your pool, its use, its environment and your own personal preferences including how you feel about modern day environmental issues. This guidebook attempts to give you as much information as possible so that you can ask important and relevant questions from your local pool contractor, pool service company or other pool support professionals. By understanding the information contained in this guide, you'll be better able to evaluate the options these professionals present from a perspective that's best for your pool environment, lifestyle and budget. In the end, you will have all the information you need to create an energy-efficient pool, giving you lowest possible heating costs and maximum enjoyment.

Why have an energy efficient pool? You want an energy efficient pool for the same reasons you want to have an energy efficient house: it reduces energy costs and increases comfort. In the same way that you can create an energy-efficient house, there are some simple and relatively inexpensive techniques that can make a dramatic difference in your pool heating costs. Plus, an energy-efficient pool has a dramatic effect on the enjoyment you and your family receive from the pool investments you make.

Perhaps you are asking yourself this question: "Why didn't I get this information directly from the pool contractor when we bought the pool?" Most likely, the answer is that pool heating has become a complex subject.

With new developments in technology and renewable energy sources, it's not as easy as it once was to provide pool heating information. Since most contractors specialize in constructing the pool, they often leave the question of heating to specialists in the field of pool heating. Or, they ignore this issue altogether within the context of the pool sale itself.

This guidebook is divided into three parts:

I. How to create an energy efficient pool environment

II. Options you have for heating your swimming pool

III. How to calculate pool heating costs

As you'll no doubt discover by reading over the contents of this guide, heating a pool can be relatively inexpensive when you have the right equipment. We've created this guidebook so you can understand the available heating options. Then you can decide the approach that makes the most sense for you, your family, and the geographical features of your pool and surrounding property.

Part I

Creating an Energy Efficient Pool Environment

The two most important components to creating energy efficient pool environments are a concept called "flowreversal" and the use of an energy-efficient pool cover.

"Flowreversal" is key to creating an energy efficient pool. Without "flowreversal," your pool is warm at the top and cold at the bottom. With the wide difference in temperature in your pool, your pool is never at the exact temperature you want. You confront the temptation to continue adding heat to make the pool comfortable. "Flowreversal" gives your pool a more uniform temperature and an accurate way to measure its temperature.

What is "flowreversal?"

Flowreversal™ is a trademark of Mark Urban of Tustin, California, whose company manufactures a line of specialty valves designed specifically for the pool and spa industry. The flowreversal™ valve is only one example. Mark Urban was issued a patent that covers this unique valve on November 11, 1986.

Despite the valve's availability for an estimated 10 years, it has only recently received the recognition it deserves. Some pool contractors are reluctant to install the valves at the time a pool is constructed because it "adds to the cost of the new pool." Progressive pool builders, however, are quick to use the valve because of its many benefits. Today, some new pools are being constructed with an "in-floor" circulation system which uses a different approach to some of the flowreversal™ concepts. We'll discuss this technology later.

What is flowreversal™ and what does it mean to you as a pool owner? These questions and others will be answered in this report as we explore the concept of having an **"energy efficient pool"** with the flowreversal™ valve. We've included graphic diagrams to help explain the concepts described and to provide you with a solid, visual understanding of the valve itself and how it is plumbed into the support system of the pool.

Be patient! You may have to read carefully to gain a complete understanding of flow reversal. It took the Patent and Trademark Office in Washington, D.C. nearly eight years before they granted a patent. Why? Because examiners at the Patent Office could not grasp the fact that water can flow through the flowreversal™ valve in two separate circuit paths at the same time.

Traditional Plumbing and Your Swimming Pool.

To understand flowreversal, you must first understand that literally millions of swimming pools have been built with a certain "traditional" plumbing configuration. This traditional plumbing means that a **"main drain"** is physically located on the bottom of the pool. The pool support pump sucks the pool water from this drain out of the pool where it is then filtered and returned to the pool through a set of **"return lines"** which are located at the top of the pool -- just a few inches just below the water line.

When a pool heater is used, it is connected to the pool support system just after the filter. The heated water is then returned through the return lines to the top of the pool. The cooler water at the bottom of the pool is pumped through the filter, heated and returned through the return lines to the top level of the pool.

There is, however, a problem with this design because **heat rises.** Traditional plumbing puts the heated water right on the top of the pool, exactly where 60-70% of the heat loss occurs. Heating the pool with this traditional approach is the same as applying heat to the <u>top</u> of a cooking pan when you're trying to boil water. It doesn't make sense. Heat should be applied to the bottom to have a more uniform temperature throughout the pool.

Why has pool construction been done this way? And why -- for the most part -- does the practice continue? The answer: **Tradition!** It's always been done that way! It all originates back to the original pool designer and his design concepts.

A main drain was located at the bottom of the pool where, in theory, particulate matter would gravitate downward and into the main drain. This "collected" particulate matter (dirt, sand, etc.) would then be trapped by the filter and clean water returned to the top of the pool via the "return lines." If a heater was employed, it didn't matter much because energy was cheap in the early years when residential swimming pools were introduced.

What's wrong with the traditional design of the pool?

The traditional design doesn't work out the way it was intended. **First, the dirt, debris and other particulate matter does not all reach the main drain**. Decades of experience show that an area of about 2-3 feet around the main drain will stay clean from the suction while the pool owner must vacuum the rest of the pool's bottom to ensure its cleanliness.

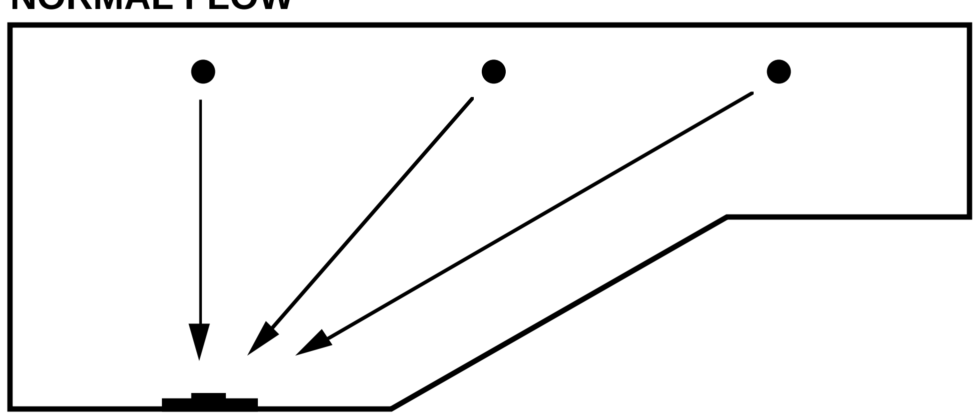
Second is the fact that inexpensive energy is a past luxury no longer available. Pool owners heating with fossil fuels or electricity can pay hundreds of dollars each month in energy costs.

Third, and again, is the fact that heat rises even if particulate matter sinks!

Illustration 1, labeled "NORMAL FLOW," shows the plumbing of a typical pool. This is a side view of a typical pool. The pool's main drain is shown on the bottom and the pool's return lines are represented by the three black circles at the top.

Illustration 1.

NORMAL FLOW



The arrows emanating from the "return lines" depict the traditional flow of water. Water flows from the top of the pool downward where it is drawn into the main drain by the pump's suction. This is normally the path of particulate matter. Again, in theory, all the dirt and other particulate matter would sink downward and be drawn into the pool's main drain. There the matter would be trapped in the strainer basket of the pool's filtration pump if it were large and trapped in the filter if the matter were small.

We know, however, that this traditional plumbing does not fulfill its design goal of keeping the pool clean. If you're already a pool owner, you no doubt have to vacuum the bottom of the pool and use a "debris collector" basket to grab leaves and other foreign materials from the bottom of the pool. In some instances, automatic pool robots clean the bottom of the pool. Enough said about the traditional design of the pool and its short comings in keeping the pool clean.

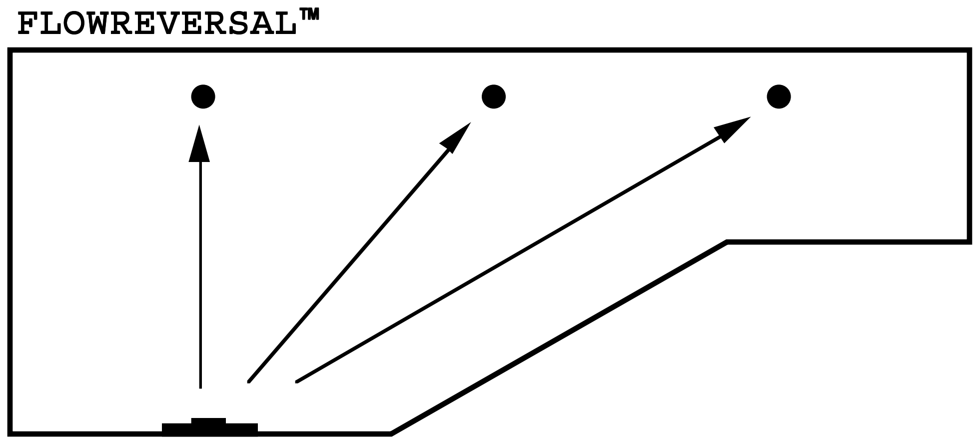
Reversing The Flow

Why couldn't we just plumb the pool backwards? Well, you could if you never needed to drain the pool. However, you still need the option of this "NORMAL FLOW" to drain out the pool water for maintenance and repairs of the pool. As you will see later, the flowreversal™ valve maintains this capability.

What is flowreversal? By now you should have guessed. If you think it is simply reversing the flow of water so that water is sucked out of the "return lines" and returned into the "main drain" --- you are absolutely right!

Illustration 2, labeled "Flowreversal" shows this process. Note that the arrows which indicate the direction of water flow are now opposite. The water flows from the "main drain" upwards and into the "return lines".

Illustration 2



***Note**: The above two illustrations are graphical depictions of the pool's plumbing for comparison purposes only and may not be representative of how your particular pool has been plumbed.*

What are the benefits?

While this concept is fairly easy to understand, it's the benefits that matter. Studies have shown that heating a pool in this manner results in a **significant reduction of heating costs!** In many cases the savings are as large as one-half to two-thirds the costs of heating the pool in the "Normal Flow" mode.

Here's why. Heat rises! In addition, water is an excellent retainer of heat. As heat rises from the main drain, it is transferred from molecule to molecule of water. Instead of having the warm water at the top of the pool and cold water below, with flowreversal you will now have an even distribution of heat throughout the pool's depth. No more warm & then cold experiences when you enter the pool. If your pool benefits from direct solar radiation onto the pool's surface -- this free heat will be immediately taken off the surface and reintroduced at the bottom of the pool. This further reduces your pool heating costs and is another direct benefit of the flowreversal valve.

Skimmer Considerations

In some pool plumbing, the skimmers are tied directly to the **"main drain"** line with a gate valve for shutoff. If we simply reversed the flow of water in the pool without doing something to the skimmers, the skimmers would blow water out onto the surface of the pool instead of "sucking" surface debris [in the flowreversal mode].

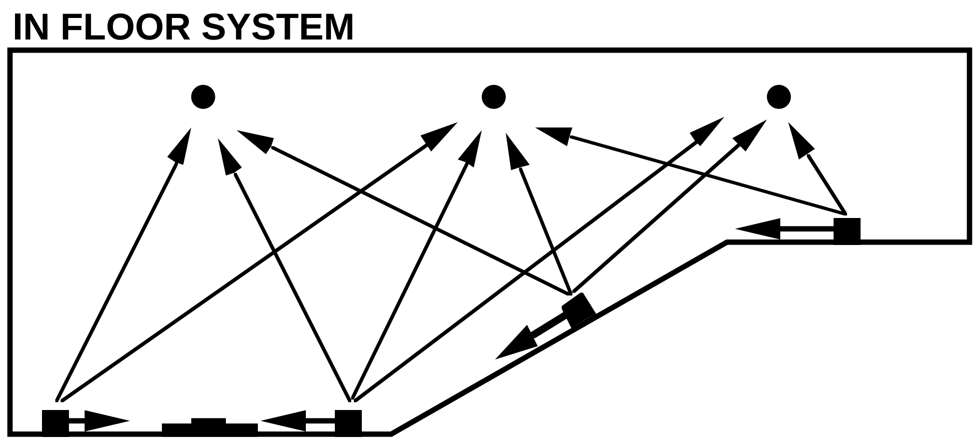
This issue is handled by a companion valve to the flowreversal valve. It is called a "proportioner valve." This "proportioner valve" is connected directly to the skimmer line, the flowreversal valve, and the pump's intake suction line. The function of this valve is to adjust the proper suction on the skimmers during reverse flow. The valve "proportions" the suction from the pump to the flowreversal valve and the skimmer line. It is set one time for proper skimmer suction but can be used to channel all of the pump's suction into the skimmer line if desired. [This is desirable when the vacuum line is connected to the skimmer line.] This "proportioner valve" is not discussed further in this report. See the swimming pool plumbing diagrams at the back of this report. They provide a systems perspective on how these special valves are installed and used.

In-Floor Circulation Systems

Some newer pools are equipped with an in-floor circulation system. The flowreversal valve will work in conjunction with some of these. Others, however, have incorporated some unique features such as "pop-ups" in the floor of the pool. These pop-ups cycle sequentially and rotate. They perform two functions. First, as they rotate -- they "sweep" the dirt on the floor towards the main drain. They also allow the water to rise in the pool creating a more efficient heating environment.

If you have an in-floor system, consult with your pool builder to determine whether or not you'll need the flowreversal valves. Some systems will benefit from it while others won't.

Illustration 3



The thick arrows in illustration 3 indicate the direction the pop ups will sweep the particulate matter which is towards the main drain. The narrower arrows show a more extensive water flow pattern created from several openings in the floor of the pool.

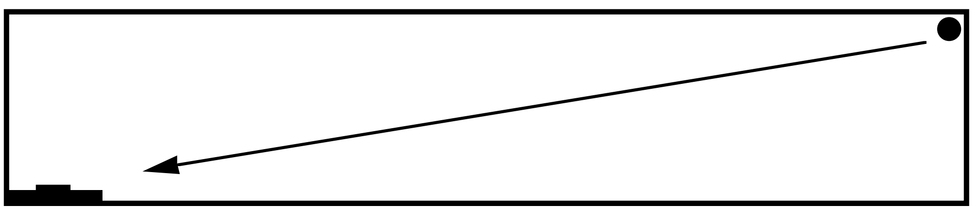
Aboveground Pools

Owners of aboveground pools do not need the flowreversal valve. They can plumb the pool so that the water rises and is drawn off of the top. This can be an important consideration since cost is a sensitive issue with most aboveground pools. Aboveground pool owners should not attempt to install "single" valves to create a flowreversal environment. It is estimated that between 6-8 gate valves would be required to duplicate the action of the single flowreversal valve. This would result in a higher cost and would be extremely confusing to use.

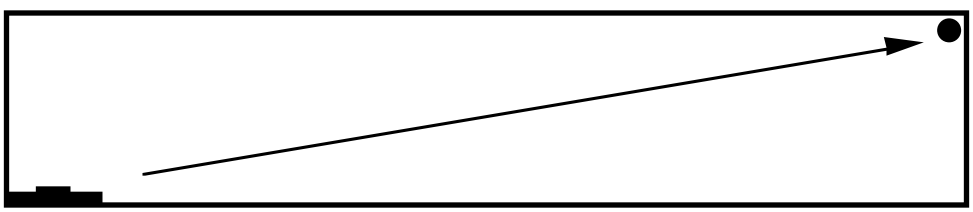
The objectives for plumbing are: a) Being able to drain the pool; b) Being able to allow the water to rise from the bottom and towards the top; and, c) Being able to winterize the pool if needed. Since the plumbing is exposed, aboveground pool owners have more options they can consider.

If cost is not an issue, using the flowreversal valve may be the best approach for aboveground pool owners. The support system plumbing will be better organized. [This assumes a main drain is being used which may not be the case.]

Illustration 4



Normal Flow



Reverse Flow

In the modified plumbing shown above as "REVERSE FLOW", water will flow from the "main drain" located in one corner of the **aboveground** pool in a **circular** fashion to the "return line" which is located in an opposite corner of the aboveground pool.

Now that you have a good idea of what the flowreversal valve does, let's examine the physical aspects of the valve.

Physical description of the flowreversal valve

As shown illustration 5, the flowreversal valve is a four port, "**X**" shaped valve. One port is connected directly to the pool's "main drain" line. A second port is connected directly to the pool's "return line." A third port is connected to the return line for the balance of the support system [i.e. line coming directly from chemical dispenser and pool heater]. The fourth port is connected to the pump's intake suction line via the proportioner valve previously discussed. All ports are 2 inch CPVC and can be reduced down to 1 1/2 inch PVC or CPVC pipe for cementing with PVC pipe cement. The top of the valve contains eight philips screws for removal of the valve's top cover and internal diverter. Either a manual handle or an automatic 24 volt a-c valve operator [VOR] can be installed on the valve.

Inside of the flowreversal valve is a midvane diverter which splits the valve into two separate sections. Water flows simultaneously into two ports and out of two corresponding ports as the midvane diverter in essence creates two separate and distinct water flow paths. No water is mixed in the valve. Just routed in different directions.

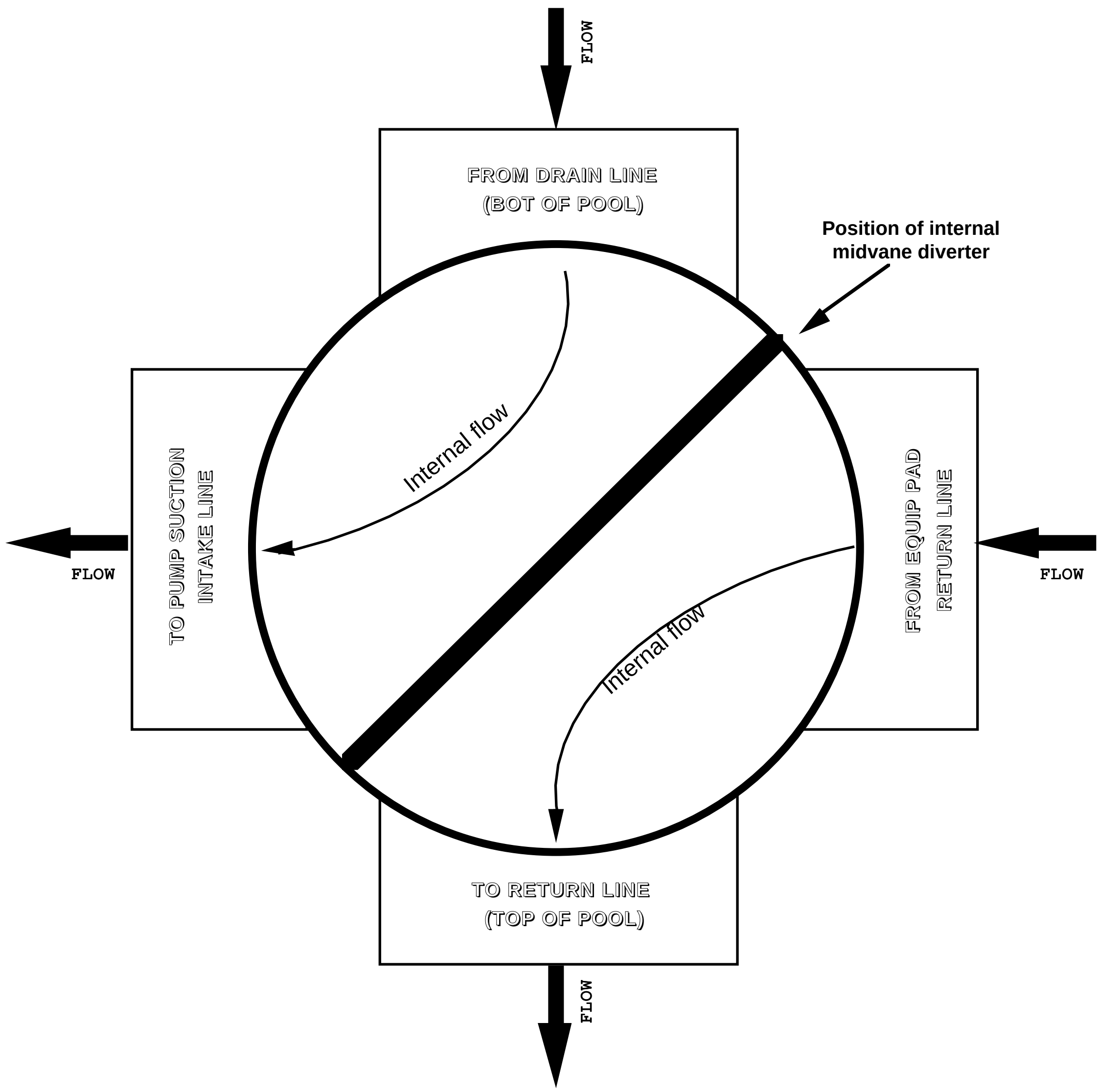
Operation of the flowreversal valve

Manual operation of the flowreversal valve is accomplished by the 90° turn of a single valve stem. When the valve is turned ninety degrees, the input to the support system which is normally the main drain is switched to the return line. Likewise, the output from the support system which normally goes to the return lines is switched so that the output of the support system goes into the main drain.

Illustration 5 shows the Flowreversal valve in its normal flow operation. Illustration 6 shows the same valve in the reversed flow mode. Illustration 7 shows the flowreversal valve with an automatic valve operator (VOR) installed on top. (Note: these graphics are smaller than the actual valve and are not drawn to any scale.)

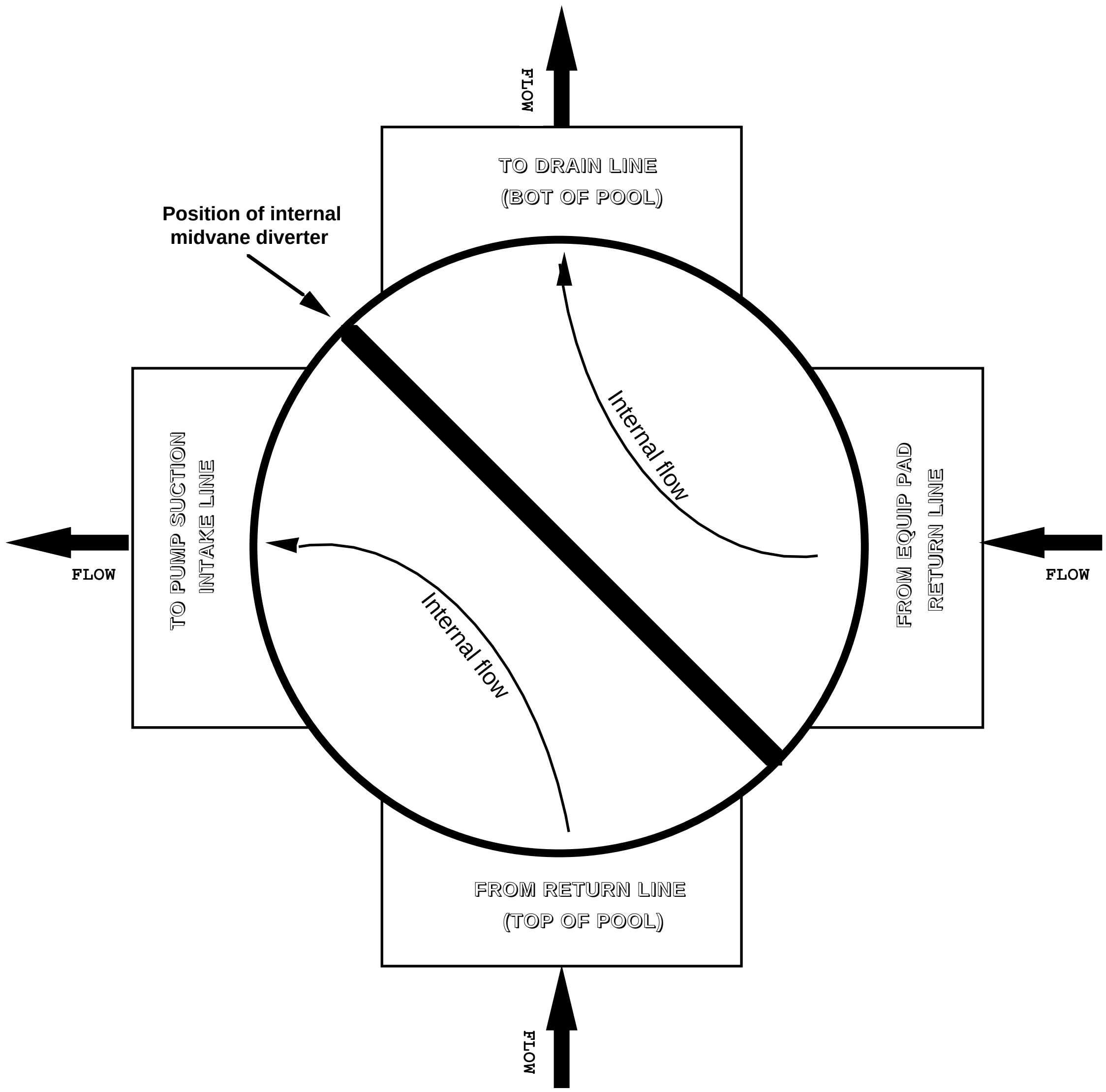
NORMAL FLOW POSITION

Illustration 5



REVERSE FLOW POSITION

Illustration 6



Automated Flow Reversal

You can achieve automatic operation of the flowreversal valve with a 24 volt A.C. valve operator (VOR). This way you can have flowreversal while heating the pool and normal flow when the pool heater is not being used. Automating flowreversal operations are not necessary with the slower heating systems such as heat pumps, solar panels, and the SolarAttic PCS1 technology.

AUTOMATED FLOWREVERSAL
with Valve Operator (VOR)

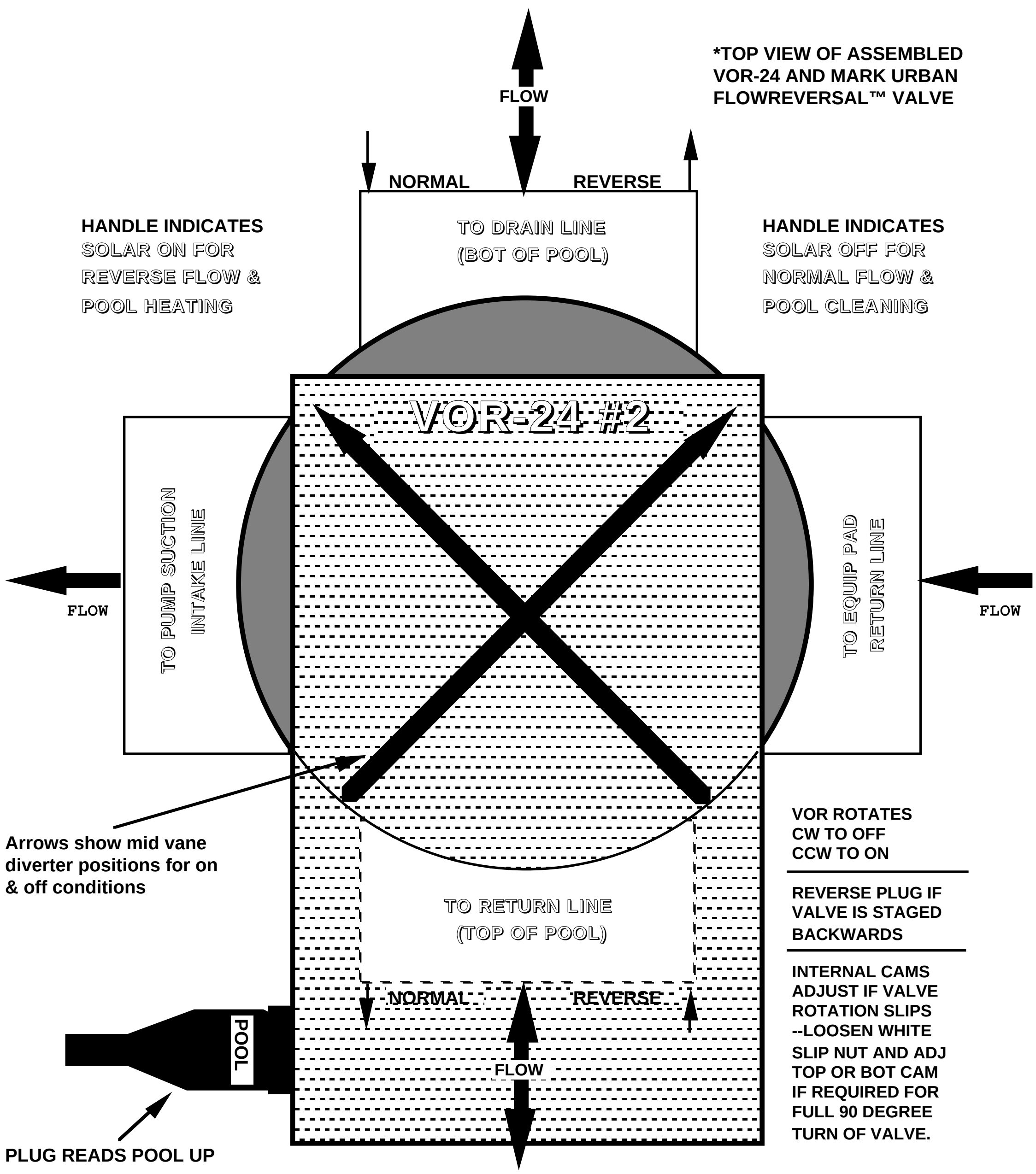


Illustration 8

BASIC PLUMBING DIAGRAM

Without Flowreversal Valves for Solar Heaters

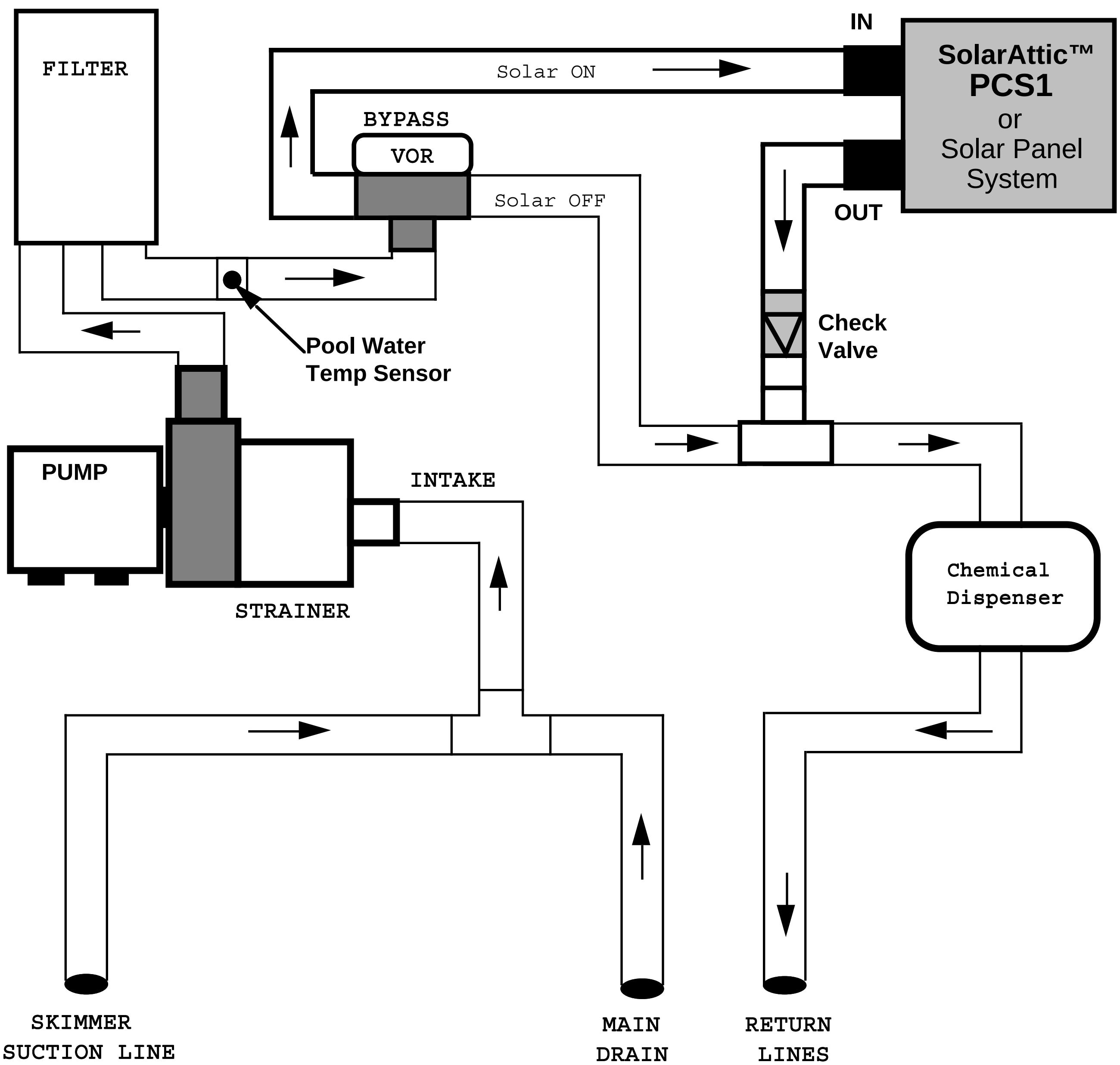
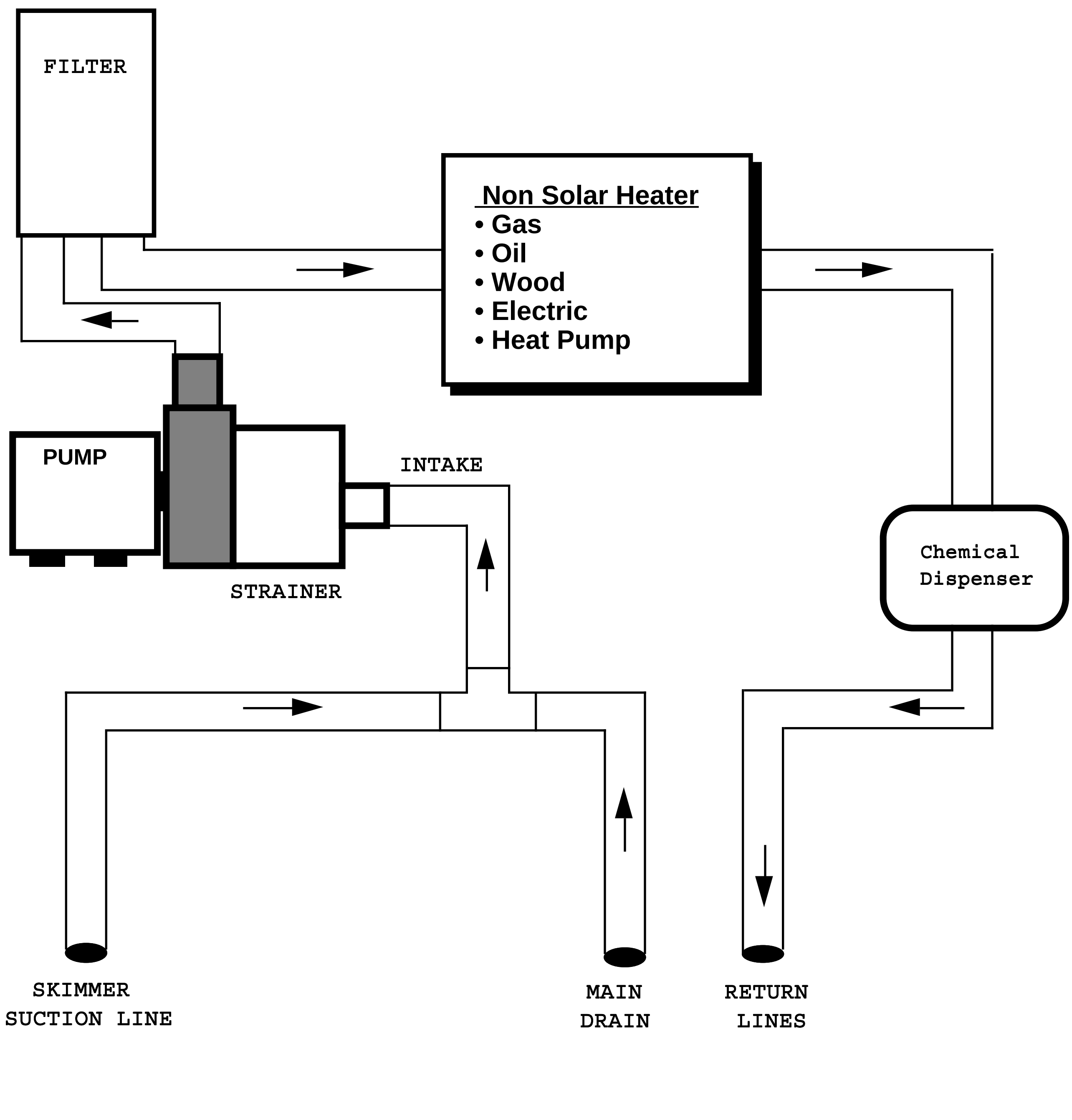


Illustration 9

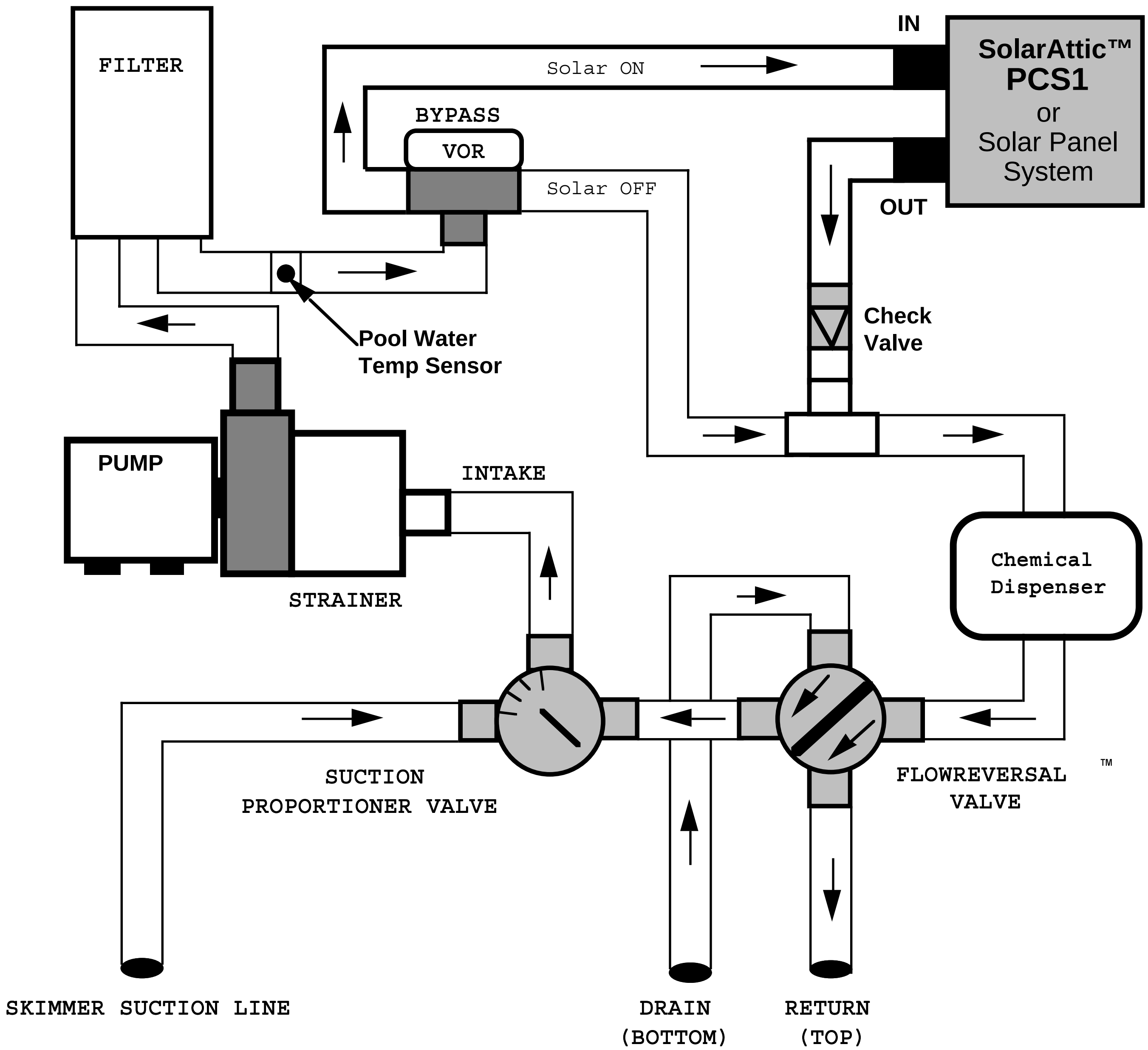
BASIC PLUMBING DIAGRAM

Without Flowreversal Valves for Non-Solar Heaters



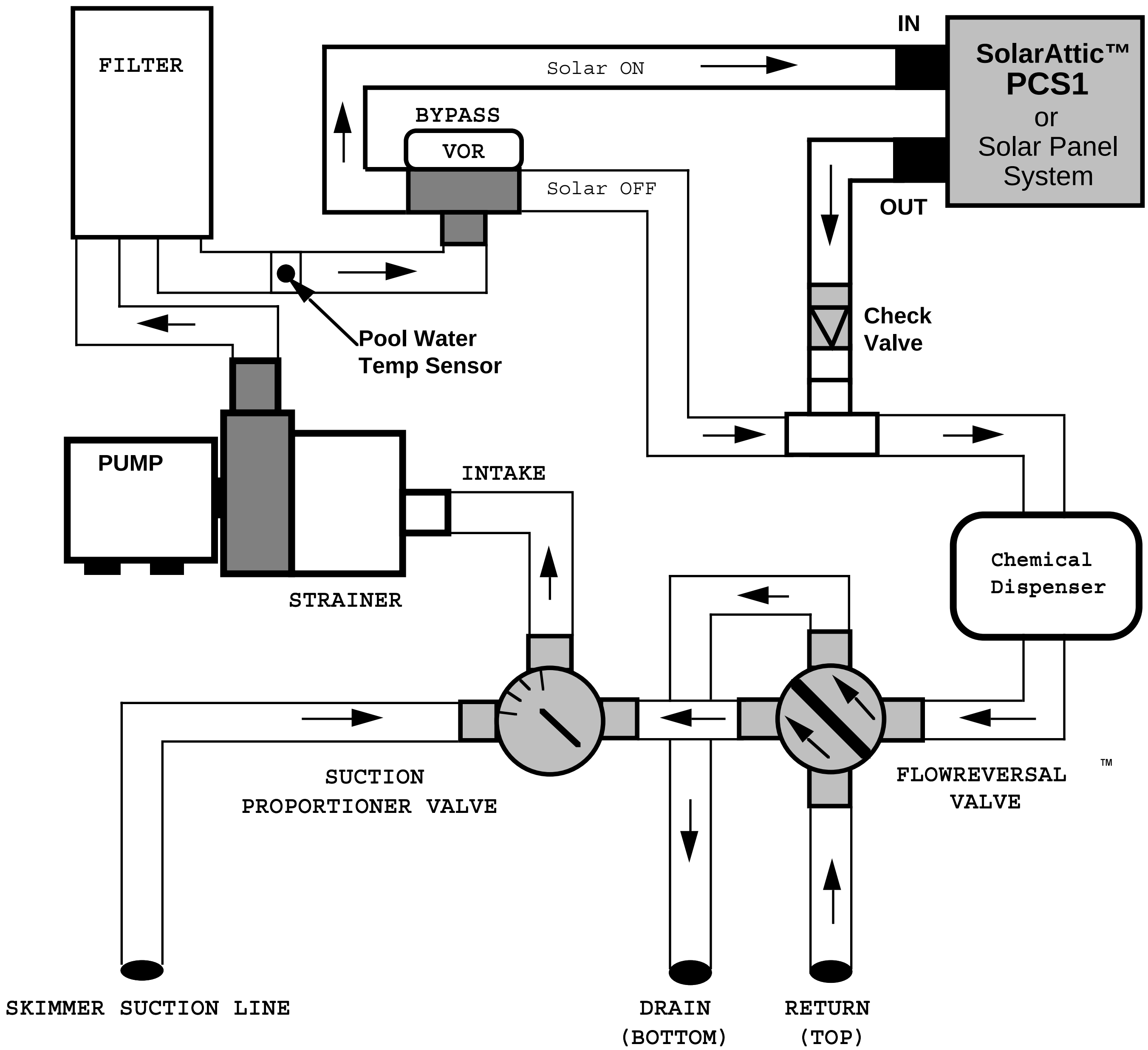
BASIC PLUMBING DIAGRAM

With Flowreversal Valves
Showing Normal Flow
with Solar Heaters



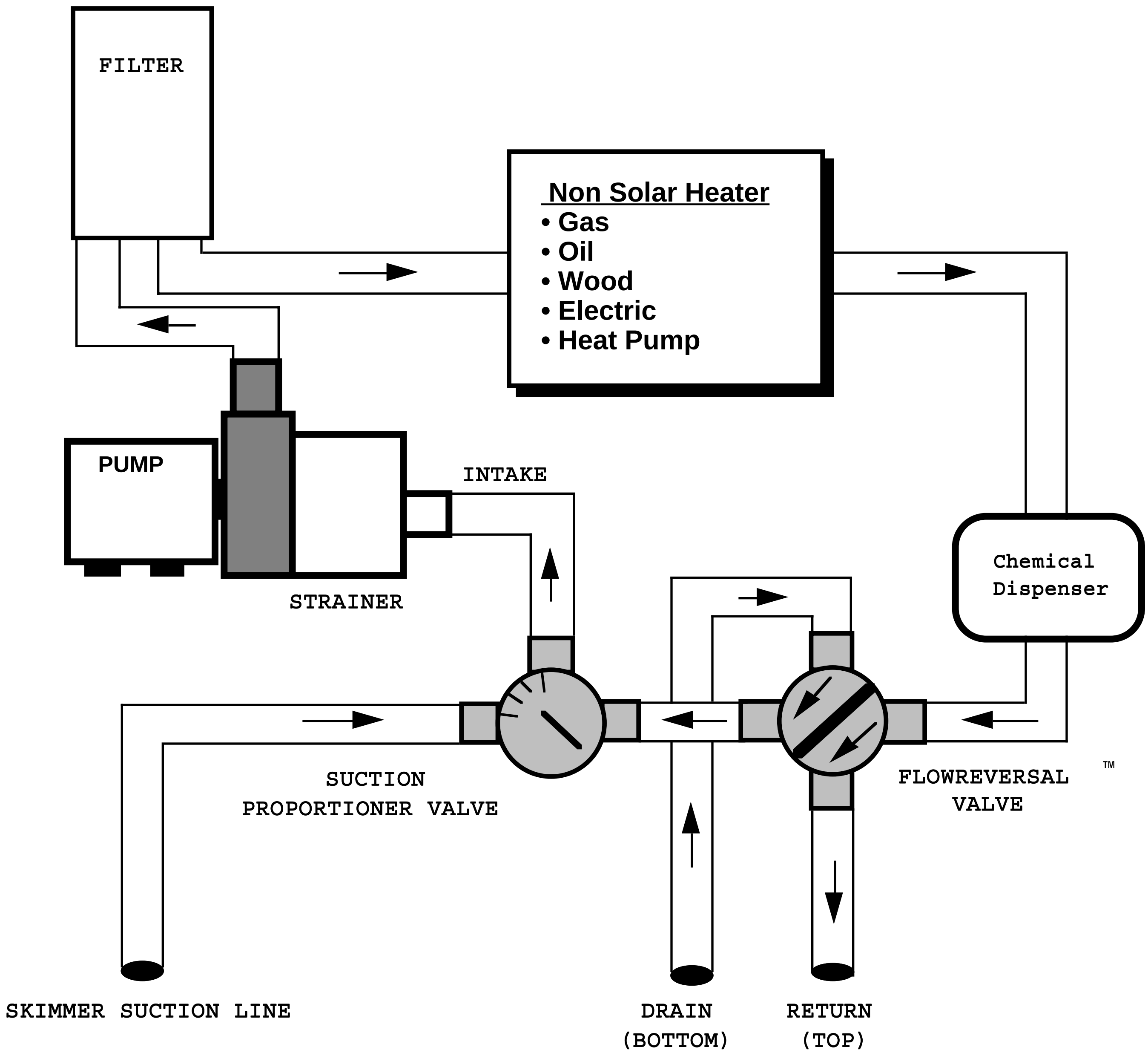
BASIC PLUMBING DIAGRAM

With Flowreversal Valves Showing Reverse Flow with Solar Heaters



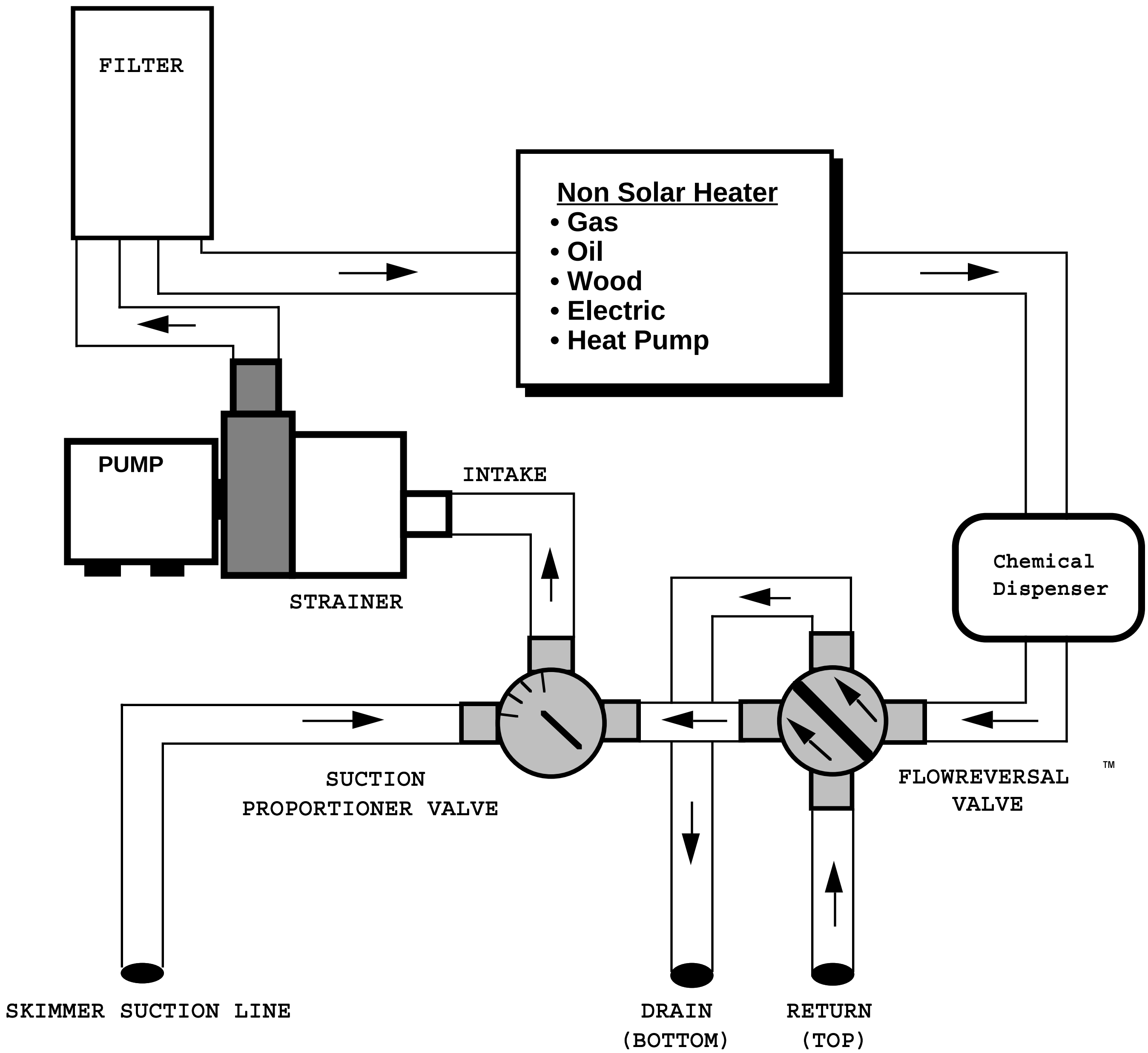
BASIC PLUMBING DIAGRAM

With Flowreversal Valves Showing Normal Flow with Non-Solar Heaters



BASIC PLUMBING DIAGRAM

With Flowreversal Valves Showing Reverse Flow with Non-Solar Heaters



It has already been stated that manual flowreversal is sufficient. In this case, the pool's visual appearance is the same as in normal flow. An area of 2-3 feet around the main drain appears clean and the rest of the pool's floor has to be vacuumed. In theory, an automated flowreversal valve will yield the best of both worlds [heating & cleaning]. When the pool is being heated, the reverse flow mode is used. When the pool is not being heated, the normal flow mode is being used.

To automate flowreversal using the SolarAttic™ PCS1 Pool Heater, an additional electronic module is added to the PCS1's LX220 solar controller to accept the second 24 volt a-c automatic valve operator [VOR].

Manual vs Automatic Flowreversal Valves

While the value of flowreversal cannot be questioned, there is debate over the value of automating the flowreversal valve. With faster-heating natural gas, propane, fuel oil or electric pool heaters, it makes some sense to use the automatic flowreversal value. With slower heating solar heaters and heat pumps, there's not much benefit to automating the flowreversal valve. We recommend a manual valve be installed in these instances. In this manner, water is constantly being recirculated from top to bottom regardless of whether the pool is being heated. In essence, the support system optimizes the heating of the pool instead of the filtration. No visual or maintenance difference has been noted in filtration or cleaning of the pool. The heating difference, however, is substantial!

Pool Blankets

The other significant feature in creating an energy-efficient pool environment is the pool blanket. But there are several misconceptions about pool blankets that we'll want to clarify for you.

First, pool blankets do not heat pools, regardless of what some people in the industry will tell you. The only purpose pool blankets serve is to prevent pool heat from escaping into the atmosphere. They serve purely as insulation -- in the same way that blankets keep people warm. Unless it's an electric blanket; the blanket itself does not supply heat. It merely serves as insulation, keeping the body heat under the blanket. The same principle applies to pool covers. All they do is keep pools from cooling off once they have been heated. Regardless of the method or fuel used to heat a pool, the pool blanket will help the pool retain the heat much longer than it would last without the pool blanket.

Second, pool blankets will work best when they are used consistently. To prevent heat loss from your pool, be sure that you cover it with a pool blanket at the end of the day -- or on cloudy days. Water retains heat well, but only when the pool blanket is used as 60-70% of the pool's heat loss occurs directly from and off of the surface of the pool.

Third, recognize that using a pool blanket often requires a lot of effort. Even pool blankets that are used in conjunction with rolling devices are sometimes difficult to maneuver. Invest in a pool blanket that's easy to use and made of durable material. The easier it is to use, the more you will probably use it.

Your Temperature Sensor

Finally, a quick note about your pool's temperature sensor. Ever wonder if it is working correctly because the water feels chilly even though the temperature reading is warm? Perhaps, the temperature sensor may more accurately reflect the top layers of heat on the pool which are caused by solar radiation, normal flow and pool blanket use. With flowreversal, the water rises from the bottom of the pool and your temperature sensor will reflect a more accurate indication of the pool's overall temperature -- the temperature you feel when you go into the pool.

Section II

Options for Heating Your Swimming Pool

When you consider pool heating technologies and systems, you have several options. In this section of the guidebook, each heating option is explained carefully so that you can select the pool heating options that make the most sense for your specific pool and its unique environment. Listed below are the specific fuel and technology options discussed in this guidebook:

Natural Gas
Liquid Propane Gas
Fuel Oil
Electric Resistance
Heat Pump
Solar Panels
SolarAttic™ PCS1 Technology

Option 1 -- Natural Gas Pool Heaters

Advantages: There are several manufacturers of natural gas pool heaters. These heaters are available in different sizes and price ranges. At the time of this writing, natural gas is the cheapest fossil fuel available in the United States. Natural gas will heat a swimming pool quickly. It is also the least polluting of all the fossil fuels.

Disadvantages: Natural gas is not available to many pool owners because they live in areas where a natural gas distribution grid is not part of the infrastructure. And, despite the fact that natural gas is less expensive than other fossil fuels, it is not uncommon to see natural gas pool heating costs ranging from $150 to $300 per month -- or more. In some cases, it can be double or triple that amount.

While natural gas provides a low level of pollution when compared to other fossil fuels, it still contributes to the collection of “greenhouse effect” environmental problems. Finally, natural gas produces a hot flame impact against the heat exchanger. This hot flame can diminish the life of the heat exchanger, the major component in this type of pool heating system.

Option 2 -- Liquid Propane Pool Heaters

Advantages: Advantages of liquid propane are similar to those for natural gas, with the notable exception being that liquid propane can be delivered to almost any location. You do not have to be on the natural gas grid to use propane as it can be stored in large storage tanks right on your property. Like natural gas, liquid propane provides fast heat.

Disadvantages: Liquid propane has the same disadvantages as natural gas, and it is significantly more expensive than natural gas.

Option 3 -- Fuel Oil Pool Heaters

Advantages: Fuel oil is readily available and can be delivered to storage tanks on the pool owner's property. Its cost varies depending on geographical area, but generally can equal or exceed that of liquid propane. Like other fossil fuels, fuel oil provides fast heat.

Disadvantages: Fuel oil heaters are not odorless, so it's best to place the fuel oil- fired pool heater away from the pool and recreational area. Energy costs can be high -- equal to or greater than that of liquid propane.

Option 4 -- Electric Pool Heaters (Electric Resistance Heaters)

Advantages: Electricity is universally available. Electric pool heaters are flameless and small.

Disadvantages: Electricity is the most expensive option for pool heating. In some areas there are peak time restrictions for heating swimming pools so pools must be heated during non-peak times only. In addition, all electric pool heating systems require special heavy duty electrical wiring and large amperage circuit breakers, making the electrical installation complicated and expensive.

Option 5 -- Swimming Pool Heat Pumps (Electricity)

Advantages: Swimming pool heat pumps use electricity (as do electric resistance heaters), but the swimming pool heat pump is 4 times more efficient than an electric resistance pool heater.

Heat Pumps Continued on next page

Option 5 -- Swimming Pool Heat Pumps (Continued)

Disadvantages: Swimming pool heat pumps contain CFC chemicals, which have been identified as major contributors to ozone layer depletion. Many nations have already signed up for the elimination of CFC chemicals in heating and refrigeration equipment by the year 2000. Once this happens, it's expected that replacement chemicals will be very expensive and obsolete equipment will be costly to rebuild or discard. This is already present in the market place with CFC 12 (freon). Expect high maintenance costs if the components housing CFC chemicals fail. This will be true on all CFC 22 and even on HCFC 134 chemicals. Heat pumps are less costly to operate than an electric resistance heater, but substantially more expensive to operate than solar systems. Heat pumps are a slower heating process than gas, oil or electric resistance.

Option 6 -- Solar energy from Solar Panels

Advantages: Solar energy is the most inexpensive source of pool heat. Solar pool heating systems are relatively inexpensive to purchase and operate. Solar energy is a totally non-polluting and completely renewable energy resource. Heating swimming pools is an ideal application for renewable solar energy. Over 90% of the solar panels sold today are used in pool heating applications.

Disadvantages: Solar panels disrupt the architectural presentation of homes, gardens and yards by requiring large panel arrays. A rule of thumb is 1:1. For every square foot of pool surface area, you will need a square foot of solar panel somewhere. This can literally take up an entire roof section on your house. Some communities restrict the use of solar panels because of their "ugly and obtrusive" visual appearance. When the sun doesn't shine, there is no available energy to heat the pool, so in critical situations, a back-up fossil fuel heater is recommended. Roof and yard mounted solar panels are exposed to the elements and can be damaged by storms, winds, or -- over time -- deterioration by the sun itself. Installation of solar panels may be difficult and/or costly depending upon the roofing materials used as well as the slope and design of the roof. Solar energy provides a slower heating process than gas, oil or electric resistance.

Option 7 -- Solar energy from hot attic air.

SolarAttic ™ Technology

Advantages: The SolarAttic™ PCS1 pool heater uses your roof and attic as the solar energy collector. The system takes advantage of solar energy (hot attic air) without having to use any type of solar panels. To heat the pool, the system converts the heat in hot attic air to warm water for the swimming pool. Inexpensive to purchase, install and operate. The heat exchanger [PCS1] fits in the attic, protected from external elements, and invisible from the outside. Cools the attic as it heats the pool. Non-polluting and renewable -- like other solar energy systems. And, this form of renewable solar energy does not have the aesthetic problems that are associated with roof mounted solar panel systems. The PCS1 fits into standard attic crawl spaces that have 3-4 feet inside the attic from its floor to its peak.

Disadvantages: As with any solar energy application, there is no available energy to heat the pool when the sun doesn't shine. In situations where pool waters must be maintained at specific temperatures, back-up fossil fuel heaters are recommended. Very small homes may not have an adequate roof or attic space. The PCS1 requires an attic at least as large as the pool's surface area which is usually not a problem. In the case of a small attic opening, adequate attic access may have to be constructed before the PCS1 can be installed which usually involves enlarging the existing opening.

Section III

Calculating Pool Heating Costs

Now that you understand how to create an energy efficient pool environment and have reviewed the various heating options available, you can easily estimate the costs of heating your pool. Section III gives you a step-by-step procedure so that you can determine what it will cost you to heat your pool with various fuels and different pool heating technologies.

Energy costs change as a result of supply and demand dynamics. Regardless, they have a tendency to go up or down at the same times since energy costs are often interrelated. Therefore, while the costs of energy may change, their relationships remain quite consistent. For comparative purposes, these calculating formulas are not affected by the day-to-day fluctuations in energy costs.

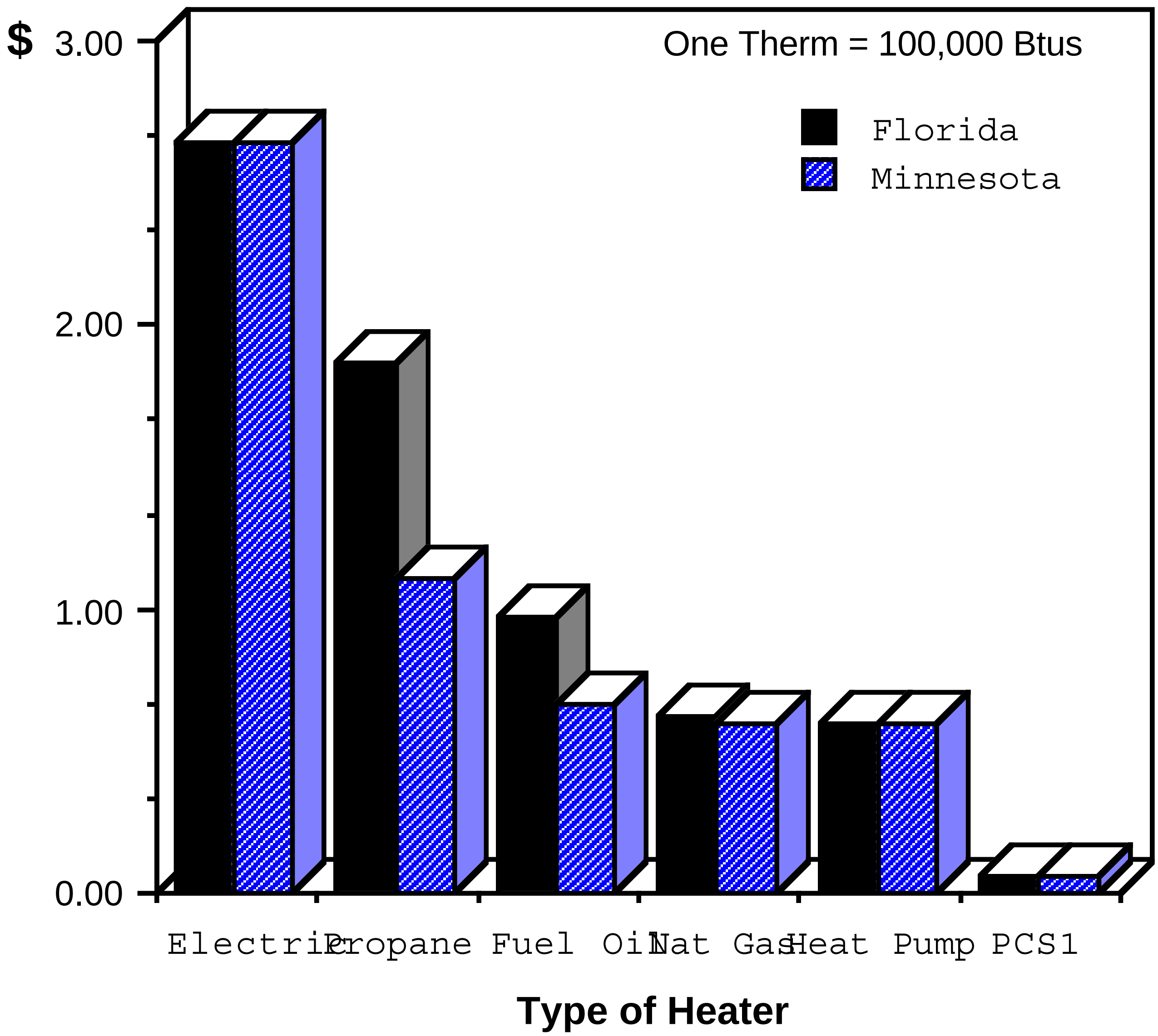
Energy Study

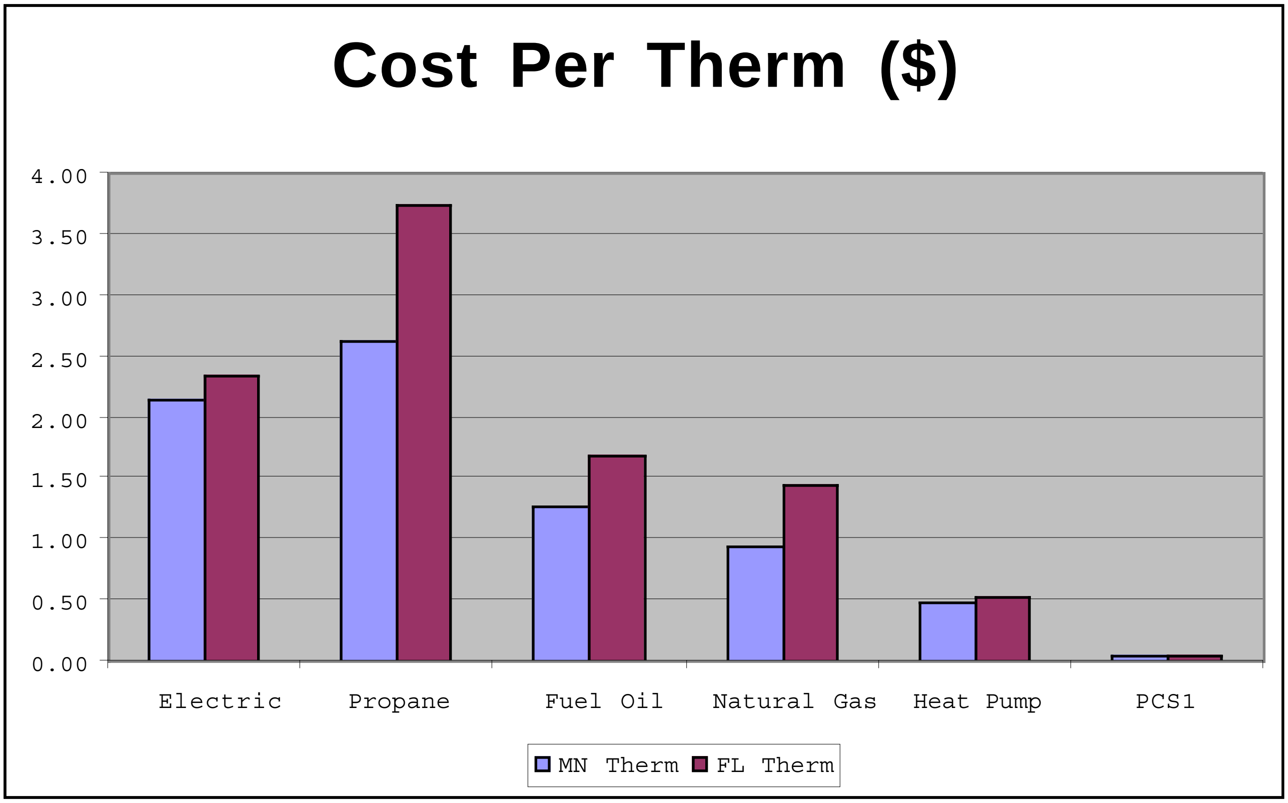
The following page illustrates the cost of various energy methods to heat pools (Illustration 14) on March 1, 1988. The following page is an update to the study made on November 22, 2000. This energy study compares energy costs in Minnesota and Florida. All of the assumptions and formulas have been included in the following pages. Local energy conditions may vary and can affect your own individual situation. The study provides a method for comparison.

How to Calculate Your Pool Heating Costs

Following the energy study data are templates for different types of swimming pool heaters. Simply fill in the appropriate numbers with your local information and perform the calculations.

Cost Per Therm





Energy Data

Minnesota	Efficien	$/Therm	$/60K BTU	$/10hr Day	$/30 Days	$/6 Months
Electric	100%	2.14	1.28	12.84	385.11	$2,310.67
Propane	70%	2.61	1.57	15.69	470.64	$2,823.85
Fuel Oil	70%	1.28	0.77	7.67	230.14	$1,380.86
Natural Gas	80%	0.95	0.57	5.68	170.33	$1,021.95
Heat Pump	440%	0.49	0.29	2.92	87.53	$525.15
PCS1	4400%	0.05	0.03	0.29	8.75	$52.52
Florida	Efficien	$/Therm	$/60K BTU	$/10hr Day	$/30 Days	$/6 Months
Electric	100%	2.34	1.41	14.07	422.04	$2,532.24
Propane	70%	3.73	2.24	22.37	671.15	$4,026.90
Fuel Oil	70%	1.69	1.01	10.13	303.79	$1,822.73
Natural Gas	80%	1.44	0.86	8.63	258.75	$1,552.50
Heat Pump	440%	0.53	0.32	3.20	95.92	$575.51
PCS1	4400%	0.05	0.03	0.32	9.59	$57.55

Energy Study Notes

Assumptions

1. This swimming pool energy cost study was originally conducted on March 1, 1988 and its results are summarized by the first graph in Illustration 14. The study was updated on November 22, 2000 and the new results are shown in Illustration 15.

2. Your costs may be higher or lower based on the cost of energy in your state and the type of fuel or heating system you are using.

3. Fuel oil and propane systems range from 60-70% efficiency. Natural gas systems range from 65-80%,

4. Heat pumps were wound to be 440% efficient on the average; based on the C.O.P. specifications of 13 heat pumps. Newer systems are slightly higher in the range of 650%.

5. "Coefficient of Performance" is the ratio of BTU output to the BTUS used [input] of a heater. PCS1 C.O.P. is 60000 ÷ 1351 = 44. Efficiency = C.O.P. x 100 = 4400%. This is the standard method used to compare performance against electric resistance heaters. The term BTU means British Thermal Unit and is the amount of energy required to raise one gallon of water one degree Fahrenheit. The THERM is a standard unit of expression and is equal to 100,000 BTUS.

6. In order to get one therm of energy into the pool, the efficiency of the heating system must be considered. It takes 142,857 BTUS input on fuel oil and propane to get 100,000 btus output of the system [input for the pool] at 70% efficiency. It takes 125,000 BTUS input to get 100,000 output [input to the pool] in a natural gas system with 80% efficiency.

7. This study assumes a new pool heater is being purchased. It therefore uses the most favorable efficiency ratings.

8. Installed systems with lower efficiencies will cost more to operate.

9. In 1988, the cost of energy had gone down making heat pump operating costs the same or higher than 80% natural gas heaters. A heat pump may not yield a payback when compared to an 80% efficient gas heater. The SolarAttic PCS1 does.

10. This study is based on the heat requirements of a 17 x 35 foot pool with 22-25000 gallons of water.

11. The PCS1 pool heater combined with Flowreversal™ and a pool blanket creates the optimum pool heating system from an energy perspective.

12. Propane and Fuel Oil are substantially higher in cost in Florida. Natural Gas and Electric rates are comparable.

Heat Pump Ratings

Manufacturer	Model #	C.O.P.	Amperage	Weight in Lbs
A	24	4.00	12.5	120
A	36	3.50 to 5.50	15.5	120
B	45	3.50 to 5.50	14.0	155
B	60	3.50 to 5.50	18.0	170
B	75	4.20	24.0	185
C	24	4.70	20.0	255
C	36	4.30	30.0	305
C	60	5.29	50.0	360
D	325	5.11	20.5	240
D	500	4.00	29.4	275
E	35	4.00	12.9	NA
E	50	4.00	17.2	NA
E	60	4.00	19.2	NA
SolarAttic	**PCS1**	**44.00**	**1.8**	**134**

Energy Sources*

Minnesota

Natural gas prices quoted by Minnegasco

Electric rates quoted by Elk River Municipal Utilities

Propane quoted by Houles Oil Company

Fuel Oil quoted by Beaudry Oil Company

Florida

Natural gas prices quoted by Peoples Gas Company

Electric rates quoted by Florida Power & Light Company

Propane quoted by Florida Propane

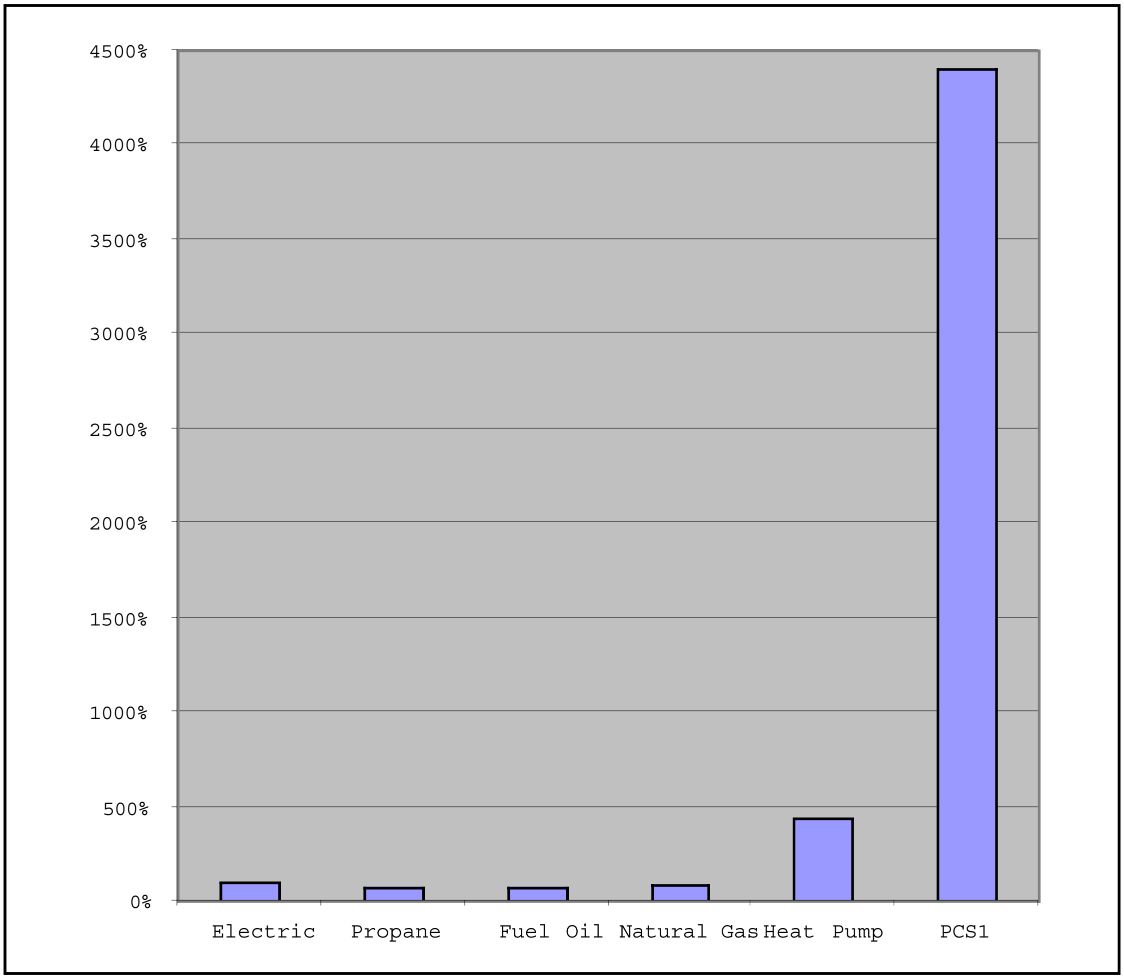
Fuel Oil quoted by Snodgrass Oil Company

*As quoted on November 22, 2000

Energy Cost Profile

Energy	Units	Minnesota	Florida
Electricity	Kilowatts	0.073	0.080
Propane	Gallons	1.690	2.410
Fuel Oil	Gallons	1.250	1.650
Natural Gas	Therm	0.757	1.150

Efficiency Graph



Formulas

A. **ONE THERM** = 100,000 BTUS

B. **C.0.P. [Coefficient of Performance]** = OUTPUT BTUS ÷ INPUT BTUS [KW x 3412]
Example: PCS1 C.O.P. is 44 = 60,000 ÷ (.396kw x 3412).

C.O.P. IS A UNIT OF COMPARISON TO ELECTRIC HEATERS.
PCS1 PRODUCES 44+ BTUS FOR EACH BTU INPUT USED.

C. **EFFICIENCY** = C.O.P. x 100
Example: 44 x 100 = 4400% efficient compared to electric heaters.

D. **INPUT REQUIRED** = 100,000 BTUS ÷ EFFICIENCY
Example: 100000 ÷ .70 propane = 142,857 input btus required.

E. **THERM INPUT COST** = (Input required ÷ btus per gallon) x per gallon cost
Example: (142857 ÷ 92310) x .72 = $1.11 for propane therm input.

F. **COST PER 60K BTU** = Therm Input Cost x .6
Example: Propane therm cost of $1.11 x .6 = $.67 for 60,000 btus of propane heat.

G. **ONE MILLION BTUS** ÷ 1000 BTUS PER CU FT = 1000 CU FT [cubic feet]
Used when Natural Gas costs are quoted in million btus.

H. **ONE MILLION BTUS** ÷ 3412 BTUS PER KW = 293.08 KW
Used when Electric costs are quoted in million btus.

I. **ONE MILLION BTUS** ÷ 92310 BTUS PER GALLON = 10.83 Gallons
Used when Propane costs are quoted in million btus.

J. **ONE MILLION BTUS** ÷ 139600 BTUS PER GALLON = 7.16 Gallons
Used when No. 2 Fuel Oil costs are quoted in million btus.

K. **ONE GALLON OF LIQUID PROPANE** = 36.2 CU FT

L. **ONE THERM OF NATURAL GAS** = 100 CU FT

M. **ELECTRIC COST** ÷ C.O.P. = HEAT PUMP OPERATING COST

N. **ELECTRIC COST** ÷ C.O.P. = PCS1 OPERATING COST

O. **HEAT CONTENT OF VARIOUS FUELS**

Electricity = 3,412 BTUS PER KILOWATT

Propane = 92,310 BTUS PER GALLON — (2550 BTUS PER CU FT)

Fuel Oil = 139,600 BTUS PER GALLON

Natural Gas = 1,000 BTUS PER CU FT — (950-1150 BTU RANGE)

How to Calculate Pool Heating Costs When You Use Natural Gas

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a swimming pool heater fueled by natural gas.

A. Cost Per Therm of Natural Gas __________
Note: Call your gas company for your rate
One Therm = 100,000 Btus
Example: 75.7¢ per Therm

B. BTU/Hour Rating of Natural Gas Heater __________
Note: Look on Gas Heater Name Plate
Or, call the pool dealer who installed heater.
Example: 150,000 Btus/hour rating.

C. Efficiency Rating of Heater __________
Note: Look on Heater Name plate **or** <u>use .8</u> (80%)

D. Therms per hour = ((B ÷ C) ÷ 100,000) __________
Note: Input btus x efficiency = Output btus (rating)
Example: 150,000 output rating ÷ .8 = 187,500
187,500 input required ÷ 100,000 = 1.875 therms/hr

E. Hours per day heater is used __________

F. Daily Operating Cost = (A x D x E) __________

<u>Example</u>:
.757 x 1.875 therms/hr x 10 hrs/day = $14.19/day

G. Days in the month heater is used __________

H. Monthly Operating Cost = (F x G) __________

<u>Example</u>:
14.19 x 20 days per month = $283.80

The cost of operating a natural gas swimming pool heater may be substantial. Many reports indicate $150 or more per week. In Minnesota during 1988, a typical natural gas heater budget for the pool season was $1000-1200.00 each year.

How To Calculate Pool Heating Costs When You Use Liquid Propane Gas

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a swimming pool heater fueled with liquid propane gas.

A. Cost Per Gallon of Propane Gas __________
Note: Call your gas company for your cost
Example: $1.69 per gallon

B. Cost Per Therm = 1.0833 x A __________
100,000 ÷ 92,210 Btus/per gallon = 1.0833 factor

C. BTU/Hour Rating of Propane Gas Heater __________
Note: Look on Gas Heater Name Plate
Or, call the pool dealer who installed heater.
Example: 150,000 Btus/hour rating.

D. Efficiency Rating of Heater __________
Note: Look on Heater Name plate **or** <u>use .7</u> (70%)

E. Therms per hour used = ((C ÷ D) ÷100,000) __________
Note: Input btus x efficiency = Output btus (rating)
Example: 150,000 output rating ÷ .7 = 214,285
214,285 input required ÷ 100,000 = 2.14 therms/hr

F. Hours per day heater is used __________

G. Daily Operating Cost = (B x E x F) __________

<u>Example</u>:
1.69 x 2.14 x 6 hrs/day = $21.70/day

H. Days in the month heater is used __________

I. Monthly Operating Cost = (G x H) __________

<u>Example</u>:
21.70 x 20 days per month = $434.00.

How To Calculate Pool Heating Costs When You Use #2 Fuel Oil

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a swimming pool heater fueled with #2 fuel oil.

A. Cost Per Gallon of Fuel Oil __________
Note: Call your oil company for your cost
Example: $1.25 per gallon

B. Cost Per Therm = .7163 x A __________
100,000 ÷ 139,600 Btus/per gallon = .7163 factor

C. BTU/Hour Rating of Fuel Oil Heater __________
Note: Look on Oil Heater Name Plate
Or, call the pool dealer who installed heater.
Example: 150,000 Btus/hour rating.

D. Efficiency Rating of Heater __________
Note: Look on Heater Name plate **or** use .7 (70%)

E. Therms per hour used = ((C ÷ D) ÷100,000) __________
Note: Input btus x efficiency = Output btus (rating)
Example: 150,000 output rating ÷ .7 = 214,285
214,285 input required ÷ 100,000 = 2.14 therms/hr

F. Hours per day heater is used __________

G. Daily Operating Cost = (B x E x F) __________

Example:
1.25 x 2.14 x 6 hrs/day = $16.05/day

H. Days in the month heater is used __________

I. Monthly Operating Cost = (G x H) __________

Example:
16.05 x 20 days per month = $321.00.

How To Calculate Pool Heating Costs When You Use Electric Resistance Heaters

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating an electric swimming pool heater.

A. Cost Per Kilowatt of Electricity __________
Note: Call your electric company for your rate

B. Kilowatt Rating of Electric Heater __________
Note: Look on heaters name plate for KW rating

<u>Alternate KW Rating Approach</u>
Determine Heater Amperage rating ________amps
Determine Heater Voltage rating ________volts
Multiply amps times volts and divide by 1000 for KW

Example: 51 amps x 240 volts = 12240 watts
12240 watts ÷ 1000 = 12.24 KW

C. Hours per day heater is used __________

D. Daily Operating Cost = (A x B x C) __________

<u>Example</u>:
.09/kw x 12.2 kw heater x 10 hrs/day = $10.98/day

E. Days in the month heater is used __________

F. Monthly Operating Cost = (D x E) __________

The cost of operating an electric swimming pool heater may be very high. Electric swimming pool heaters are usually the most expensive pool heaters to operate.

How To Calculate Pool Heating Costs When You Use A Pool Heat Pump

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a heat pump designed to heat swimming pools.

A. Cost Per Kilowatt of Electricity __________
Note: Call your electric company for your rate

B. Kilowatt Rating of Heat Pump Heater __________
Note: Look on Heat Pump Name Plate

Alternate KW Rating Approach
Heater Amperage rating = _______Amps
Heater Voltage rating = _______ Volts
Multiply amps times volts and divide by 1000 for KW

Example: 12 amps x 220 volts = 2640 watts
2640 watts ÷ 1000 = 2.64 KW

C. Hours per day heater is used __________

D. Daily Operating Cost = (A x B x C) __________

Example:
.09/kw x 2.64 kw heater x 10 hrs/day = $2.37/day

E. Days in the month heater is used __________

F. Monthly Operating Cost = (D x E) __________

Example:
2.37 x 30 days per month = $71.10

The above example calculations are for a very a small heat pump. Many heat pumps my be twice as expensive to operate. Note also the high maintenance cost that can arise if the CFC chemical system in the heat pump fails. Order or download free our special report "How To Understand Pool Heat Pumps" for additional information.

How To Calculate Pool Heating Costs When You Use Solar Panels

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a pool heating system that is based on roof or yard mounted solar panels. If the solar panel system you are considering uses only the pool's support system pump for water circulation, then the solar panel system operating costs are negligible. Except for system purchase, installation and repair, the heat is totally free.

A. Cost Per Kilowatt of Electricity __________
Note: Call your electric company for your rate

B. Kilowatt Rating of Booster Pump [if needed] __________
Note: Stop here if you have no booster pump.
Operating costs are negligible.

<u>Alternate KW Rating Approach</u>
Booster Pump Amperage rating = 1.8 Amps
Booster Pump Voltage rating = 220 Volts
Multiply amps times volts and divide by 1000 for KW

Booster Pump = 1.8 amps x 220 volts = 396 watts
396 watts ÷ 1000 = .396 KW

C. Hours per day heater is used (MAXIMUM) **10**

D. Daily Operating Cost = (A x B x C) __________

<u>Example</u>: 10 hours per day is typical run time
.09/kw x .396 kw heater x 10 hrs/day = $.35/day

E. Days in the month heater is used __________

F. Monthly Operating Cost = (D x E) __________

<u>Example</u>:
.35 x 30 days per month = $10.50

The cost of operating a solar panel system to heat your swimming pool is low. The only operating cost is for recirculating water. If you use the existing pool pump, additional costs are not incurred with the solar panel pool heater. A small cost can be attributed to the solar controller's electrical consumption, but it is usually insignificant.

How To Calculate Pool Heating Costs When You Use The SolarAttic™ PCS1

This is a cost estimating template. Simply fill in the appropriate numbers and perform the simple calculations shown. This template will help you to determine the cost of operating a swimming pool heater that coverts hot attic air into swimming pool heat.

A. Cost Per Kilowatt of Electricity __________
Note: Call your electric company for your rate

B. Kilowatt Rating of SolarAttic PCS1 Heater **.396**

Alternate KW Rating Approach
Heater Amperage rating = 1.8 Amps
Heater Voltage rating = 220 Volts
Multiply amps times volts and divide by 1000 for KW

SolarAttic PCS1= 1.8 amps x 220 volts = 396 watts
396 watts ÷ 1000 = .396 KW

C. Hours per day heater is used (MAXIMUM) **10**

D. Daily Operating Cost = (A x B x C) __________

Example: 10 hours per day is typical run time
.09/kw x .396 kw heater x 10 hrs/day = $.35/day

E. Days in the month heater is used __________

F. Monthly Operating Cost = (D x E) __________

Example:
.35 x 30 days per month = $10.50

Operating the SolarAttic™ PCS1 swimming pool heater only involves the small amount of energy required to operate the PCS1's fan motor. A small electrical consumption can be attributed to the solar controller, but like solar panel systems this is an insignificant amount of electricity.

Monthly & Annual Operating Costs

Depending upon fuel used and weather conditions, your monthly operating costs will be different. Use the monthly figures you calculated on the preceding pages in lines F, H or I to compare annual results below.

Your Pool Heating Option	$ From Line	Monthly Cost	X	Months Used	=	Annual Cost
NATURAL GAS	**H**		**X**		=	
LIQUID PROPANE GAS	**I**		**X**		=	
FUEL OIL	**I**		**X**		=	
ELECTRIC RESISTANCE	**F**		**X**		=	
HEAT PUMP	**F**		**X**		=	
SOLAR PANEL	**F**		**X**		=	
SOLARATTIC PCS1	**F**		**X**		=	

LONG-TERM COSTS

To determine the lifetime costs associated with each technology, you can use the following formula guidelines. Plug in the annual operating costs from the above exercise and calculate according to the stated formula below. For comparative purposes, you can assume a 10-year heater life and ignore maintenance factors. Maintenance is an issue, however, and one can expect to replace fossil fuel heaters and heat pumps within 5-7 years. Roof mounted solar panel systems can require moderate maintenance and have a design life exceeding 10 years. The SolarAttic™ PCS1 is relatively maintenance free with a design life exceeding 10 years.

Cost of Gas, Oil, Electric or Heat Pump heater $____________________

+ Installation cost $____________________

+ 10 X annual energy costs $____________________

Total $____________________

Divided by 10 years **÷ 10**

Actual Yearly cost $____________________

Cost of Solar Panel System $____________________

+ Installation cost $____________________

+ 10 X annual energy costs $____________________

Total $____________________

Divided by 10 years **÷ 10**

Actual Yearly cost $____________________

Cost of SolarAttic™ PCS1 $____________________

+ Installation cost $____________________

+ 10 X annual energy costs $____________________

Total $____________________

Divided by 10 years **÷ 10**

Actual Yearly cost $____________________

Conclusion

You invest in a swimming pool for enjoyment. If you're like most people, you will find that a heated pool is far more enjoyable than a non-heated one.

We hope that this **Guide to Swimming Pool Heating** has helped you develop a strategy to create an energy efficient, comfortable and enjoyable swimming pool. If you have questions about this report or the guide to help you calculate your pool heating costs, please contact us. We always welcome questions or comments on pool heating topics, so please call or write us with them.

We have included a technical reference section as "Appendix A" which follows. Whenever a solar panel system or the SolarAttic Pool Heater (PCS1) is purchased, a common question is: "Will my existing pool pump be able to handle the added pumping requirement (vertical lift or extra head of pressure)? In almost all cases, this answer is yes. However, there are exceptions. The technical reference section can help you determine whether your specific pump can handle the additional load.

If you would like more detailed information on SolarAttic's PCS1 Pool Heating System or other SolarAttic™ Technology products, please call, fax or write.

SolarAttic, Inc.

Mailing Address
15548 95th Circle NE
Elk River, MN 55330-7228

Phone: (763) 441-3440
Fax: (763) 441-7174
EMail: info@solarattic.com

Appendix A

REFERENCE INFORMATION

This technical information will help you determine if your pump is the proper size for handling the additional "head" (in feet) of either a solar panel system or the SolarAttic Pool Heater (PCS1).

FRICTION LOSS IN 1 1/2" PLASTIC PIPE

Feet of head per 100 feet of Schedule 40 PVC pipe

Flow Rate (Gallons per Minute)	**Velocity** (Feet per Second)	**Friction Loss** (Feet per 100 feet of pipe)
4	.63	1.50
5	.79	.225
6	.95	.300
7	1.10	.400
8	1.26	.520
9	1.42	.630
10	1.58	.770
12	1.89	1.07
14	2.21	1.39
16	2.52	1.76
18	2.84	2.11
20	3.15	2.58
22	3.47	2.98
24	3.78	3.60
26	4.10	4.20
28	4.41	4.70
30	4.73	5.30
32	5.04	5.85
34	5.36	6.40
36	5.67	7.00
38	5.99	7.85
40	6.30	8.50
42	6.62	9.20
44	6.93	9.80
46	7.25	10.06
48	7.57	10.15
50	7.88	10.24
55	8.67	10.45
60	9.46	10.69

FRICTION LOSS IN 2" PLASTIC PIPE

Feet of head per 100 feet of Schedule 40 PVC pipe

Flow Rate (Gallons per Minute)	**Velocity** (Feet per Second)	**Friction Loss** (Feet per 100 feet of pipe)
7	.67	.12
8	.77	.15
9	.86	.19
10	.96	.23
12	1.15	.34
14	1.34	.44
16	1.53	.56
18	1.72	.68
20	1.91	.83
22	2.10	.98
24	2.29	1.15
26	2.49	1.33
28	2.68	1.56
30	2.87	1.74
35	3.35	2.20
40	3.82	2.86
45	4.30	3.40
50	4.78	4.30
55	5.26	5.00
60	5.74	5.80
65	6.21	6.70
70	6.69	7.50
75	7.17	8.60
80	7.65	9.55
85	8.13	10.7
90	8.61	11.8
95	9.08	13.2
100	9.56	14.4

FRICTION LOSS IN FITTINGS

Equivalent length of straight pipe in feet

Size of Pipe '	**1/2"**	**3/4"**	**1"**	**1 1/4"**	**1 1/2"**	**2"**	**3"**	**4"**
Gate valve (open)	0.6	0.7	0.9	1.2	1.3	1.6	2.0	2.7
90° Elbow	3.6	4.5	5.3	6.7	7.5	8.6	11.1	13.1
45° Elbow	0.7	0.9	1.4	1.8	2.2	2.8	4.1	5.6
Tee (straight thru)	1.8	2.5	3.3	4.7	5.7	7.8	12.1	17.1
Tee (thru side)	4.3	5.4	6.7	8.8	10.0	12.1	17.1	21.2
Swing check valve	8.1	8.9	11.2	13.1	15.2	19.1	27.1	38.2

POOL GALLONAGE

Formula: Length x Width x Average Depth x 7.5 = Total Pool Gallons

Average Depth	3.5 Feet	4.0 Feet	4.5 Feet	5.0 Feet	5.5 Feet
Pool Size	**Gallons**				
10 x 20	5300	6000	6800	7500	8300
11 x 22	6400	7300	8200	9100	10000
12 x 24	7600	8600	9700	10800	11900
14 x 28	10300	11800	13200	14700	16200
15 x 30	11800	13500	15200	16900	18600
16 x 32	13400	15400	17300	19200	21100
18 x 36	17000	19400	21900	24300	26700
19 x 38	19000	21700	24400	27100	29800
20 x 40	21000	24000	27000	30000	33000
22 x 44	25400	29000	32700	36300	39900
23 x 46	27800	31700	35700	39700	43600
25 x 50	32800	37500	42200	46900	51600
26 x 52	35500	40600	45600	50700	55800
27 x 54	38300	43700	49200	54700	60100

CONVERSION TABLE - I

POUNDS PRESSURE (Head in feet of water)

Pounds Pressure	Feet of Head	Pounds Pressure	Feet of Head
1	2.31	19	43.9
2	4.62	20	46.2
3	6.93	25	57.7
4	9.24	30	69.3
5	11.6	35	80.8
6	13.9	40	92.4
7	16.2	45	103.9
8	18.5	50	115.5
9	20.8	55	127.0
10	23.1	60	138.6
11	25.4	65	150.1
12	27.7	70	161.7
13	30.0	75	173.2
14	32.3	80	184.8
15	34.7	85	196.3
16	37.0	90	207.9
17	39.3	95	219.4
18	41.6	100	231.0

CONVERSION TABLE - II

INCHES OF MERCURY (Head in feet of water)

Inches Mercury	Feet of Head	Inches Mercury	Feet of Head
1	1.13	16	18.13
2	2.27	17	19.26
3	3.40	18	20.39
4	4.53	19	21.53
5	5.67	20	22.66
6	6.80	21	23.79
7	7.93	22	24.93
8	9.06	23	26.06
9	10.20	24	27.19
10	11.33	25	28.33
11	12.46	26	29.46
12	13.60	27	30.59
13	14.73	28	31.72
14	15.86	29	32.86
15	17.00	30	33.99

COST OF RUNNING A MOTOR

@ 10 CENTS PER KILOWATT HOUR

Motor HP	Hourly Cost	8 Hour Day	Cost Per Week	Cost Per Month	Cost Per Six Mos.	Cost Per Year
1/2	$.05	$.40	$2.80	$12.13	$72.80	$145.60
3/4	.075	.60	4.20	18.20	109.20	218.40
1	.10	.80	5.60	24.36	145.56	291.12
1 1/2	.15	1.20	8.40	36.40	218.40	436.80
2	.20	1.60	11.20	48.53	291.20	582.40
3	.30	2.40	16.80	72.80	436.80	873.60

EQUIPMENT AND PIPE SIZING FOR A HYDRAULICALLY BALANCE POOL OR SPA

All calculations are based on the National Hydraulic Institute's recommendation of a pipe velocity of 7 feet per second (f.p.s.) or less.

Gallons (Per Minute) GPM	**Pipe Size** (Inches)	**Friction Loss** (For 100 Feet of Pipe)	**Minimum Size***		
			DE Filter (Sq Ft)	**Sand Filter** (Sq Ft)	**Cartridge**** (Sq Ft)
30	**1 - 1/4**	11.1	20	2.0	2 - 20
40	**1 - 1/2**	8.9	27	2.7	2 - 26
50	**1 - 1/2**	13.5	33	3.3	2 - 33
60	**2**	5.6	40	4.0	2 - 40
70	**2**	7.4	47	4.7	2 - 46
80	**2**	9.5	53	5.3	2 - 53
90	**2 - 1/2**	5.0	60	6.0	2 - 60
100	**2 - 1/2**	6.1	67	6.7	2 - 66

*Filters calculated at most efficient flow rate.

**Dual Cartridge filters.

DETERMINING THE MAX FLOW RATE BY THE SIZE OF PIPING

GALLONS PER MINUTE FLOW RATE (GPM) @
7 FEET PER SECOND MAX FLOW VELOCITY

Pipe Size (Inches)	**Flow Rate (GPM)**
1	18
1 - 1/4	33
1 - 1/2	44
2	75
2 - 1/2	110
3	160

CALCULATING THE POOL'S TURNOVER RATE

This is the time (in hours) that is required to filter the entire volume of water in the pool.

FORMULA:

$$\text{TURNOVER RATE IN HOURS} = \frac{\text{POOL GALLONS}}{\text{PIPE FLOW X 60}}$$

EXAMPLE:

25,000 GALLON POOL WITH 1 - 1/2" PIPE

$$\frac{\text{25,000 GALLONS}}{\text{44 X 60}} = \text{9.47 HOURS}$$

NOTES:

1. Obtain maximum pipe flow rate from preceding table. For 1 - 1/2" pipe, this number is 44 gallons per minute.

2. The factor 60 is the number of minutes in an hour. This converts the rate in minutes to an hourly figure.

3. If you are experiencing difficulty keeping your pool clean, it may be an indication that your turnover rate is too high. Or, that your pool's pump and/or filter are too small. You can check the proper sizing of the pump and filter equipment with the preceding sizing charts.

4. If you add a solar panel system or the SolarAttic Pool Heater (PCS1) to your pool, in most instances, it will not affect the performance of your pool. Pool pumps that are sized properly are capable of handling the additional vertical lift (head in feet) that a solar system places on the pool's filtration pump. However, if your pump was marginally sized to begin with, you may have to increase the size of the pump by 1/2 horsepower.

5. An exception to #4 exists when extraordinary lengths or heights (over 250 ft round trip) are involved in getting the pool's water to/from the solar system. In this case, you need to check the "performance curve" for your specific pump.

6. A one (1) horsepower pump can usually handle a 250 feet round trip with a vertical lift of 20-30 feet. You can be absolutely sure of this by checking your own pump's performance curves.

TOTAL DYNAMIC HEAD CALCULATION

USING A PRESSURE GAUGE AND VACUUM GAUGE

Make sure the filter is clean when the pressure gauge and vacuum gauges are read. The pressure gauge is typically on the top of the filter and measures the pressure on the output of the discharge side of the pump. Therefore, the pressure gauge is a measure of the head loss on the discharge side. The vacuum gauge is placed on the pump's intake suction side to measure the head loss on the suction side. Both numbers have to be multiplied by conversion factors and then added to get the total dynamic head. This method is the most accurate because you are measure the results of your existing system. Why go to all this trouble measuring/calculating? To verify proper sizing of your pool's filter and pump. Especially if you have problems with pool cleanliness.

Step 1

Multiply the pressure gauge reading times 2.31. This equals the head loss on the discharge side of the pump.

Step 2

Multiply the vacuum gauge reading times 1.13. This equals the head loss on the suction side of the pump.

Step 3

Add the two totals together to obtain the total head loss in the system.

Example:

Pressure gauge reads 20 pounds. Vacuum gauge reads 10 inches of mercury. Therefore

Pressure gauge	20 x 2.31	=	46 feet of head
Vacuum gauge	10 x 1.10	=	<u>11 feet of head</u>
Total Dynamic Head		=	57 feet of head

Alternate Method to Calculate Total Dynamic Head

Useful when a vacuum gauge and/or pressure gauge is not available and you want to get a general picture of the pool's dynamic head for checking the pump sizing when adding a solar panel system or the SolarAttic Pool Heating (PCS1)

A. Vertical Lift = 20 feet	Estimate the distance in feet from the pool's pump to the top of the solar panel system or to the inlet of the PCS1.
B. Suction Lift = 10 feet	Estimate the distance in feet that the water is lifted from the bottom of the pool to the pump's intake.
C. Horizontal Pipe = 200 feet	Estimate the total horizontal distance from the pump to the solar system. This is the distance <u>one</u> way.
D. Total Horizontal Run = 2 times the horizontal pipe. CALCULATION: = 200 x 2 = 400 feet of pipe	Calculate the total horizontal pipe run from the pool's pump to the solar system.
E. Pipe Friction Loss per 100 feet of pipe = 5	Obtain the friction loss in feet of head per 100 feet of 2 inch Schedule 40 PVC pipe at 55 gpm flow rate. Loss increases if flow rate increases. You have to measure or estimate the flow rate. See prior table for the friction loss of pipe (per 100 feet).
F. Horizontal Friction Loss = Total Horizontal Run ÷ 100 x Friction Loss per 100 ft CALCULATION: = 400 ÷ 100 = 4 x 5 = 20	This calculation provides the friction loss caused by the horizontal pipe run within 2" pvc pipe at 55 gpm.
G. Total Dynamic Head = Vertical Lift + Suction Lift + Horizontal Friction Loss CALCULATION: = 20 + 10 + 20 = 50 feet of head	Total Dynamic head is expressed in feet that the pump must operate against. This simplified formula ignores the effects of the pools pipe fittings. See prior method for a more accurate calculation of dynamic head.
H. Nominal Pressure = 50 ÷ 2.31 = 21.6 PSI	Nominal Pressure in System = (Total head ÷ 2.31)
I. Pipe flow rate estimate = 50 gallons per minute	Measure or estimate of flow rate. Derated with the above conditions and ideally obtained from a pump's performance characteristic curve. You can obtain such a curve from your pool dealer or pump manufacturer.
J. Gallons in pool = 28,000	Measure or estimate of pool gallons.
K. Turnover = Gallons ÷ Flow rate. CALCULATION: = 28,000 ÷ 50 = 9.3 hours	How long it takes to turn over the water in the pool as a result of the above projected pipe run/friction and the pump's curves.