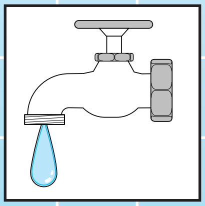
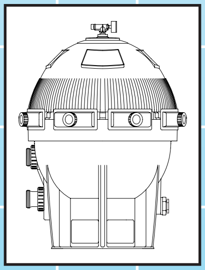
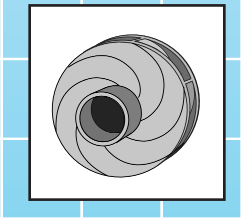
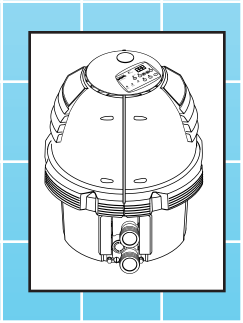
Sta-Rite Industries
Basic Training Manual

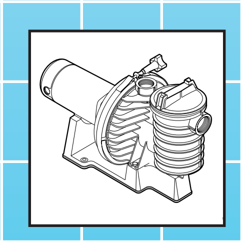
THIRD EDITION











Hydraulics

Pumps

Motors

Filtration

Heaters

STA-RITE®

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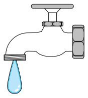

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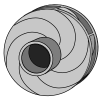
Hydraulics



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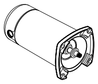

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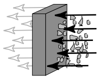

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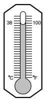

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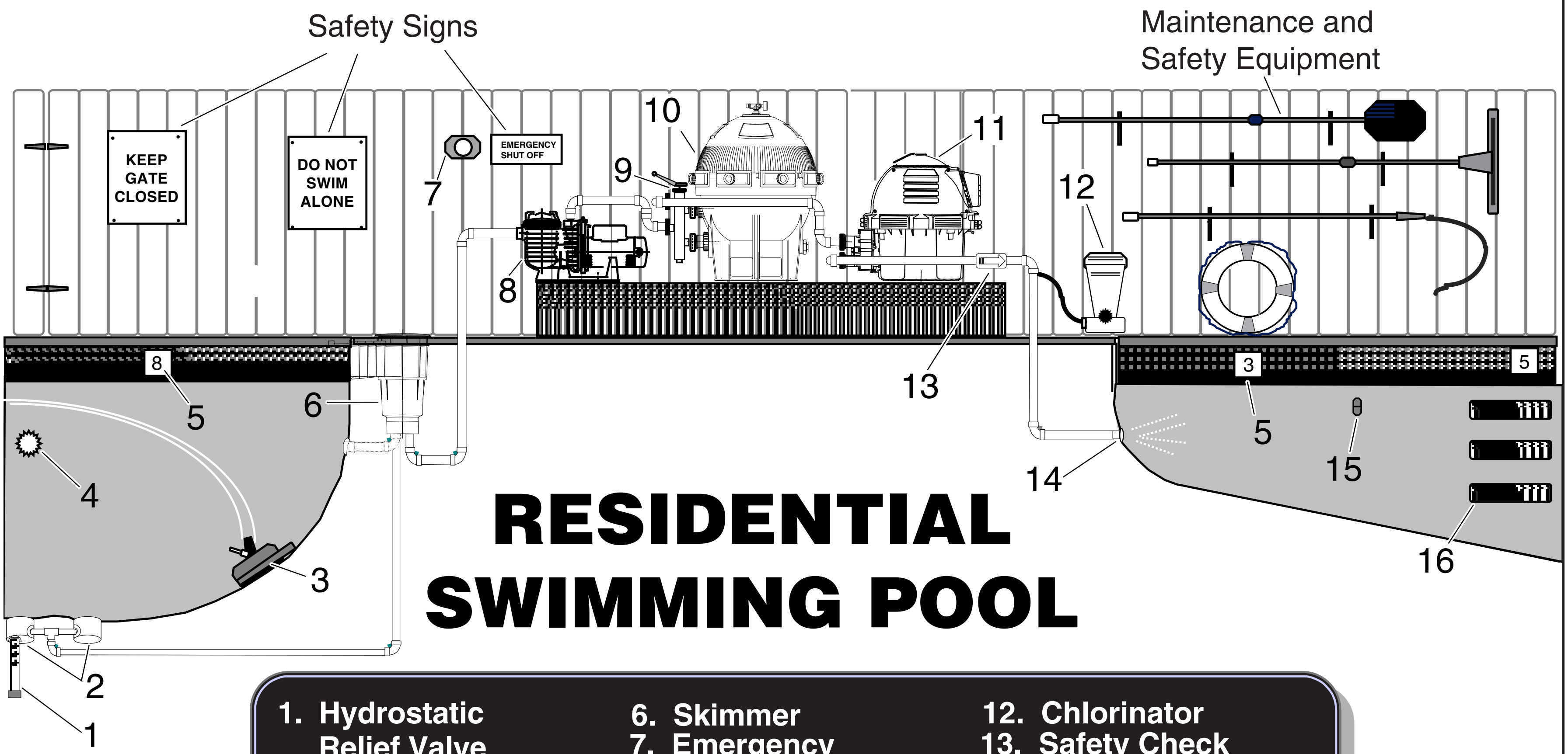
RESIDENTIAL SWIMMING POOL



1. **Hydrostatic Relief Valve**
2. **Dual Main Drains**
3. **Automatic Cleaner**
4. **Underwater Light**
5. **Depth Marker**
6. **Skimmer**
7. **Emergency Shutoff Switch**
8. **Pump**
9. **Backwash Valve**
10. **Filter**
11. **Heater**
12. **Chlorinator**
13. **Safety Check Valve**
14. **Return Fitting**
15. **Cup Anchor**
16. **Recessed Steps**

Figure 1

RESISTANCE

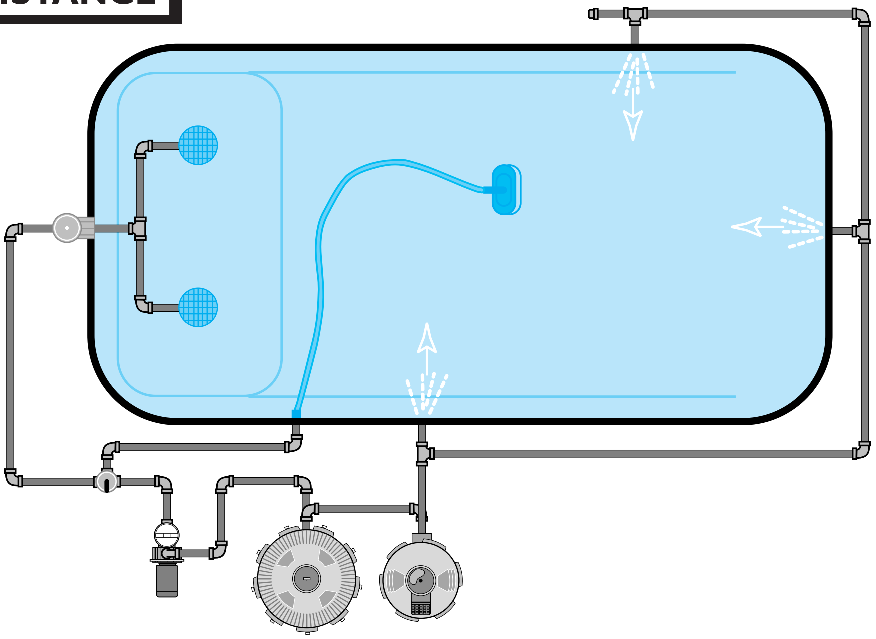


Figure 2

Hydraulics

Hydraulics, as used in this text, deals with the physical movement of water for the many purposes associated with swimming pools, spas, and water features.

These purposes include the following:

- Passing the water through a filter to remove the suspended particles.
- Moving the water through a heater, solar system or other device for the purpose of raising or lowering the water temperature. (1)
- Providing enough flow of water with the right amount of force to operate a pool cleaner or cleaning system.
- Delivering the right amount of water flow to operate several therapy jets for spas.
- Supplying water flow to sanitizing devices such as chlorinators, brominators, and ozone generators.
- Providing the right flow for the many types of fountains, water falls, water slides, wave pools, and other specialty applications used with pools and spas.

In order to move water for the above purposes, we must examine how we make it flow efficiently. We need to know what restricts flow and how to calculate the resistance. Once we understand flow and resistance, we can overcome these obstacles to deliver the desired results. **This is the purpose of the section on hydraulics.**

Water Flow

Water flows naturally downhill. Unfortunately, we can't design a swimming pool, spa, or water feature so that the water is always following gravity. To provide water flow for all the different tasks associated with a pool, spa, or water feature, we use a pump. The pump, which will be discussed in Section II, draws and pushes the water through pipes, fittings, filters, heaters, etc., used in the operation of a pool, spa, or water feature. These objects create resistance to flow that the pump must overcome.

Examine the basic pool plumbing layouts in Figures 1 and 2. List the objects that cause the resistance the pump must overcome to deliver the proper amount of flow.

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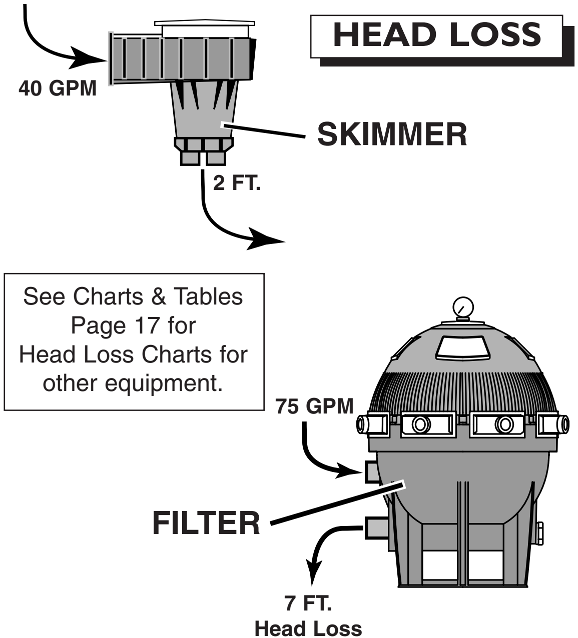
(1) In many very hot areas of the world, solar systems are used at night to lower the temperature of the water.



See Charts & Tables Page 17 for Head Loss Charts for other equipment.

Figure 3

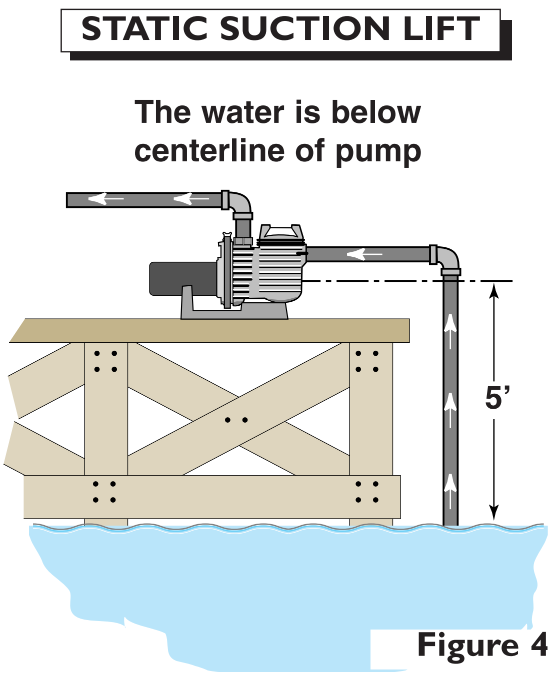


Figure 4

Friction Head Loss

The resistance to flow (Friction Head Loss) is expressed in FEET OF HEAD. For example, see Figure 3: Water flowing at 40 GPM (gallons per minute) through a 2” skimmer will result in 2 ft. of head loss. 75 GPM through a 53 sq. ft. D.E. will result in 7.0 ft of head loss.

Static Suction Lift

The vertical distance between the center line of the pump impeller and the surface level of the water is called the static suction lift. This distance can be expressed as Positive Suction Head or Negative Suction Head. Both are expressed as Feet of Head.

1. Positive Suction Head – Pump is located below the surface of the water. This can be a standard centrifugal or a self-priming centrifugal pump.
2. Negative Suction Head – Pump is located above the surface of the water. This type of pump is usually considered a “Self Priming Pump”.

Example:

A pump located 5’ above the surface of the water will add 5 ft. of head loss to the system. (Figure 4)

A pump located 5 ft. below the surface of the water will reduce system head loss by 5 feet. This is due to the weight of the water assisting the pump.

Elevation - Atmospheric Pressure

Atmospheric pressure on the surface of the water helps a self-priming centrifugal pump to perform. The higher the elevation that the pump is installed, the pressure on the surface of the water decreases. This decrease reduces the amount of work a given pump can do.

Example:

The ability of a pump to lift water is reduced by 1.155 ft. of head for every 1,000 ft. of elevation.

A pump that lifts water 10 ft. at sea level will only be able to lift water 8.845 ft. at an elevation of 1,000 ft. At 5,000 ft. of elevation, that same pump will only be able to lift water 4.225 ft., or in other words, a reduction of over 50% in the pump’s capacity to lift.

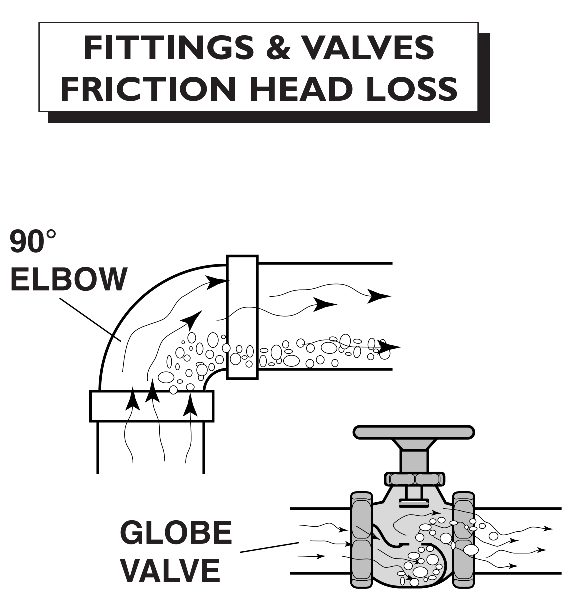


Figure 5

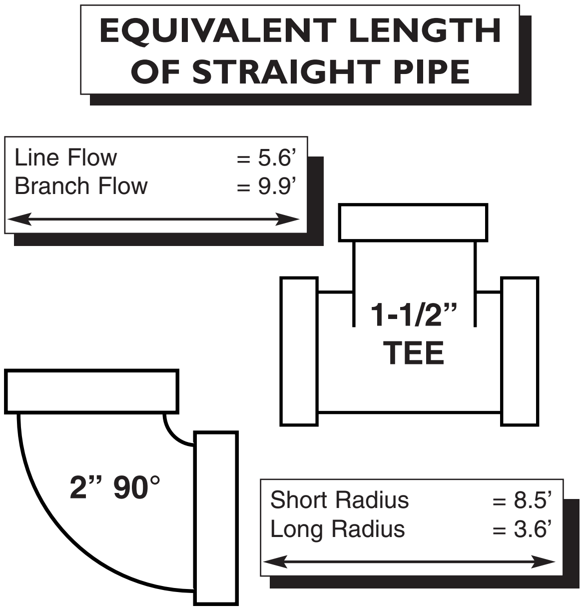


Figure 6

Fittings And Valves - Friction Head Loss

When water flows through fittings and valves, turbulence is created in the water, which can result in cavitation. These two phenomena produce a significant amount of friction head loss. (See Figure 5).

Important Note: Unlike filters, heaters, skimmers, etc., we do not express the resistance in fittings and valves as head in feet. Instead, it is stated as **"EQUIVALENT LENGTH OF STRAIGHT PIPE."**

Example:

One 2″ 90° PVC elbow is expressed as 8.5 ft. of 2″ pipe. A sweep 2″ PVC 90° is expressed as 3.6 ft. of 2″ pipe. (See Figure 6)

Why is a sweep 90° equivalent to a shorter length of pipe than a 90° elbow?

____

____

What is the difference in friction head loss between a Branch Flow Tee and a Line Flow Tee?

____

____

Using the Charts and Tables Manual, Pages 36 & 37, complete the following chart. (Use the Screwed/Steel numbers. They are equivalent to PVC pipe.)

What is the equivalent length of pipe?

1 - 1½″ 90° elbow ______________________________

1 - 3″ branch flow tee ______________________________

1 - 1½″ globe valve ______________________________

2 - 2″ 45° elbows ______________________________

4 - 1½″ gate valves ______________________________

1 - 3″ line flow tee ______________________________

How much less equivalent length of pipe are 2 45° elbows than 1 90° elbow?

____

Now compare one sweep 1½″ 90° with two 1½″ 45° elbows.

____

Calculate the equivalent length of pipe savings in a plumbing layout that was designed with ten 2″ regular 90° ells that will be replaced with twenty 2″ 45° ells.

Ten 2″ 90° regular ells = __________ft.

-Twenty 2″ 45° ells = __________ft.

Equivalent Length of Pipe Savings =__________ft.

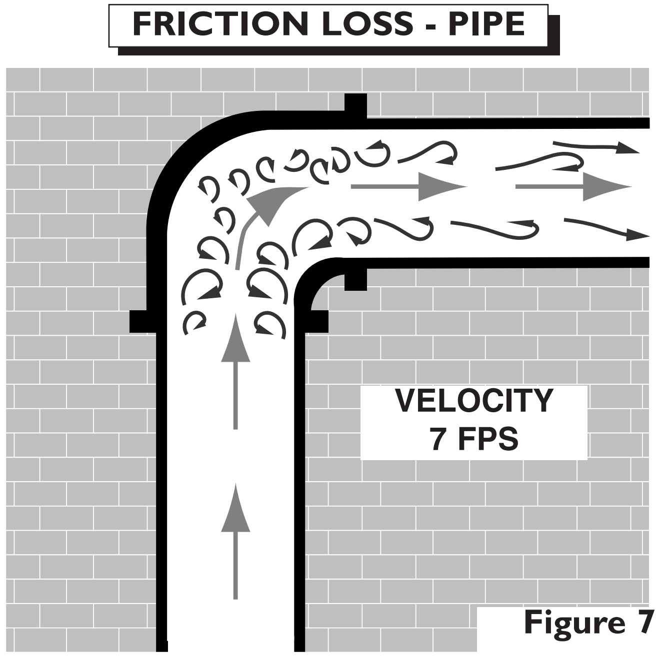


Figure 7

FRICTION FLOW CHART

1-1/2” PVC Pipe (100 ft. lengh)

GPM	VELOCITY (FPS)	FRICTION HEAD (FT.)
20	3.15	2.47
40	6.30	8.90
80	12.60	35.00
160	25.20	140.00

Figure 8

Pipe Sizing

There are other factors that can cause resistance in the plumbing system. The major factor affecting the efficiency of water flow is VELOCITY.

Velocity is a term used to express the speed at which the flow of water travels through a pipe and fittings. The velocity of the water is measured and expressed in feet per second (FPS).

The velocity of water flowing through a pipe and fittings is determined by two factors:

1. The volume or quantity of flow (GPM).
2. The size of the pipe through which the water is moving.

As water flows through the pipe (Figure 7), it encounters friction from the pipe walls. The faster the water moves, the more friction it encounters. In fact, if we double the flow in a given pipe, the velocity will double, and friction loss will increase **approximately 4 times.**

Pipe - Friction Head Loss

As you see in the Friction Flow Chart for 1½” schedule 40 PVC pipe (Figure 8), 40 GPM travels at a speed of 6.30 FPS through the 1½” pipe. At this speed, the amount of friction loss will be 8.9 ft. of head for each 100 ft. Length of pipe.

If the flow were doubled to 80 GPM through the same 1½” pipe, the speed of the water doubles to 12.60 FPS. **However, and more important, the friction head loss increases almost 4 times to 35 feet of head.**

Due to the rapid increase in friction head loss as the flow increases in a given pipe, we follow the recommendations of the Hydraulic Institute for suction pipe sizing.

Schedule 40 PVC pipe ....velocity is 7 FPS

Copper Pipes ....velocity is 6 FPS

Polyethylene Coil Pipe ....velocity is 5 FPS

Using the Charts and Tables, Page 29, determine as closely as possible the flow (GPM) at or near 7 FPS for each of the following Sched. 40 PVC pipe.

3/4” ____________ 1 “ _____________ 1¼” ____________

1½ “ ____________ 2 “ _____________ 2½” ____________

3” _________ 4” _________ 6” _________ 8”_________

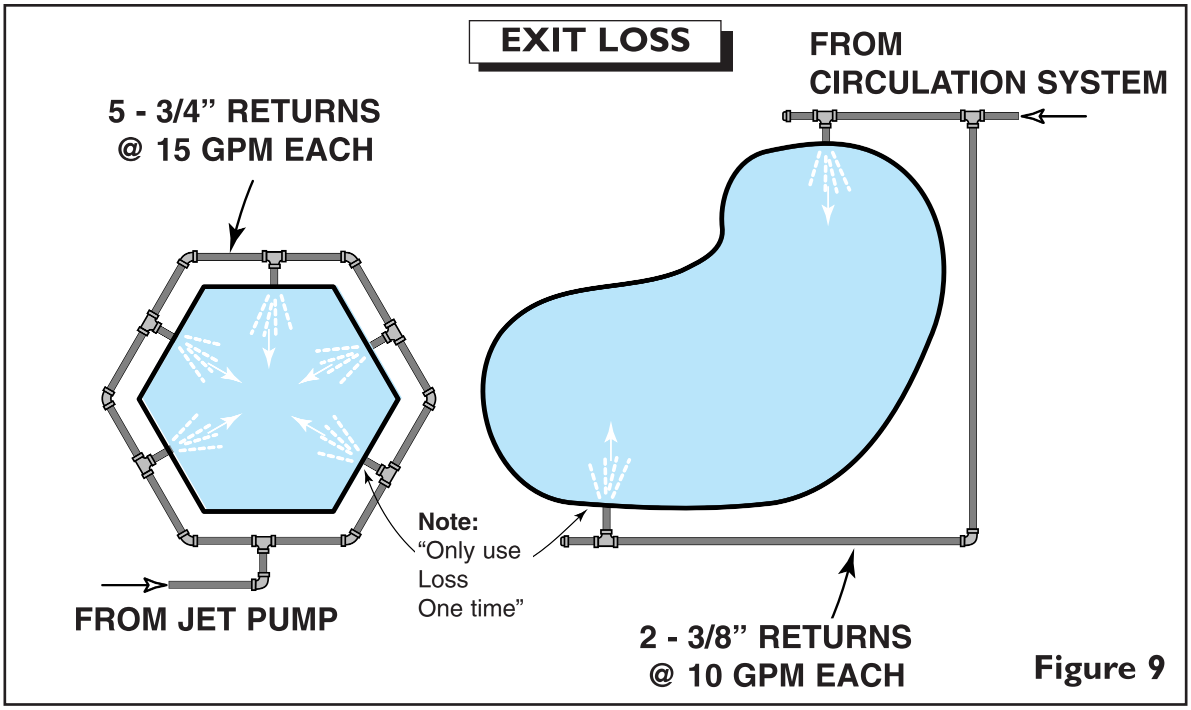


Figure 9

Exit Loss

Exit loss occurs on the "discharge" side of the pool, spa, or water feature's circulation system, also know as the "return side". This loss occurs as a result of the water being discharged from the orifices in the return inlets fittings into the large body of water.

The resistance created by the exit loss is calculated as Velocity Head Loss in Feet. This exit head loss is part of the total head loss on the discharge side of the pump. **Exit Loss Charts are provided in the Charts and Tables, Page 18.**

NOTE: An important thing to remember is that this resistance is not cumulative. You only add the head loss one time, regardless of the number of return fittings.

Example:

A pool with three 1" return lines, each moving 20 GPM, will add 1.04 ft. of head to the discharge head loss. (The head for one fitting only)

Using the chart on **Page 18** of the Charts and Tables, fill in the following Exit Head Losses.

Five 3/4" return lines flowing 15 GPM each will add________ft. of head to the discharge head loss.

Two 3/8" return lines flowing 10 GPM each will add________ft. of head to the discharge head loss. (See Figure 9).

System Head Loss or Total Dynamic Head Loss (TDH)

As we have read in previous pages, many things contribute to the resistance to flow that the pump must overcome. Skimmers, main drains, fittings, pipe size, velocity, heaters, filters, automatic cleaning systems, and elevations are some of these obstacles. We know that these factors have resistance values that can be calculated. Once calculated and combined they are known as the Total System Head Loss or TDH (Total Dynamic Head).

We now can begin calculating the System Head Loss. The steps necessary are as follows:

1. DETERMINE THE REQUIRED FLOW RATE

There are several steps we must follow to calculate the flow rate. Two factors are necessary for any body of water.

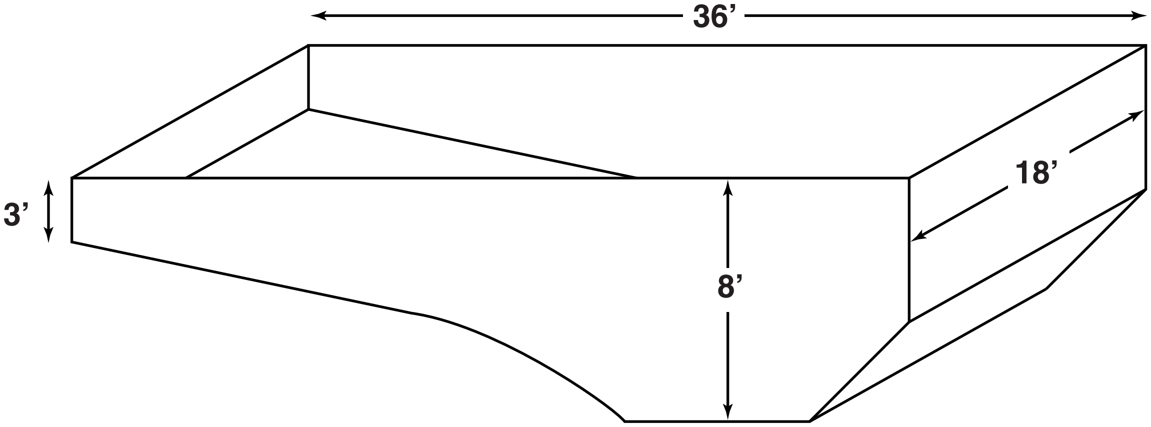
A. How many gallons are we dealing with?

B. What is the desired turnover rate?

A. SWIMMING POOL GALLONS

It is a simple matter to calculate the gallonage of a square or rectangle swimming pool. Free formed pools, such as ovals and kidney shapes are much more difficult. **Page 40** of the Charts and Tables shows some additional formulas for free formed pool.

SWIMMING POOL GALLONS



Gallons = L x W x AD x 7.48

Figure 10

A. Swimming Pool Gallons

Figure 10 is a rectangle shaped swimming pool. To calculate the amount of water in the swimming pool, the first step is to determine the square feet of surface area.

Length x Width = surface area square footage.

The second step is to find the average depth. (AD) This is accomplished by taking at least 2 measurements. One at the shallow end and the other at the deepest point of the pool.

3 feet + 7 feet = 10 feet/ 2 = a AD of 5 feet.

The Third step is to multiply the square footage times the average depth to get cubic feet.

sq. ft. x AD = cubic feet

The final step is to multiply the cubic feet by 7.48 (The number of gallons in a cubic foot)

Cubic Feet x 7.48 = gallons

Example:

Calculate the gallons for the swimming pool in Figure 10.

Length_____x ____Width_____x AD_____x 7.48

Equals______Gallons.

B. Turnover Rate

Each time the total volume of water in a swimming pool, spa or water feature is passed through the filter, it is said to have “turned over” once. Although the “turnover rate” should be the number times that a complete turnover occurs in 24 hours, we usually talk about the number of hours it takes to turn over the water once.

Example:

A body of water passing through a filter 3 times in 24 hours is considered to have an “8-hour turnover”.

If 4 “turns” are required in 24 hours, then a “6-hour turnover” is required.

If a “12-hour turnover” is needed, then all the water will pass through the filter twice in 24 hours.

Gallons Per Minute (GPM)

To determine the GPM, we divide the total body of water by the number of minutes in the turnover hours.

Example:

A 30,000 gallon pool with an 8 hour turnover:

30,000 / 480 (8 X 60) = 62.5 GPM

What is the GPM for a 30,000 gallon pool with a 6-hour turnover?__________

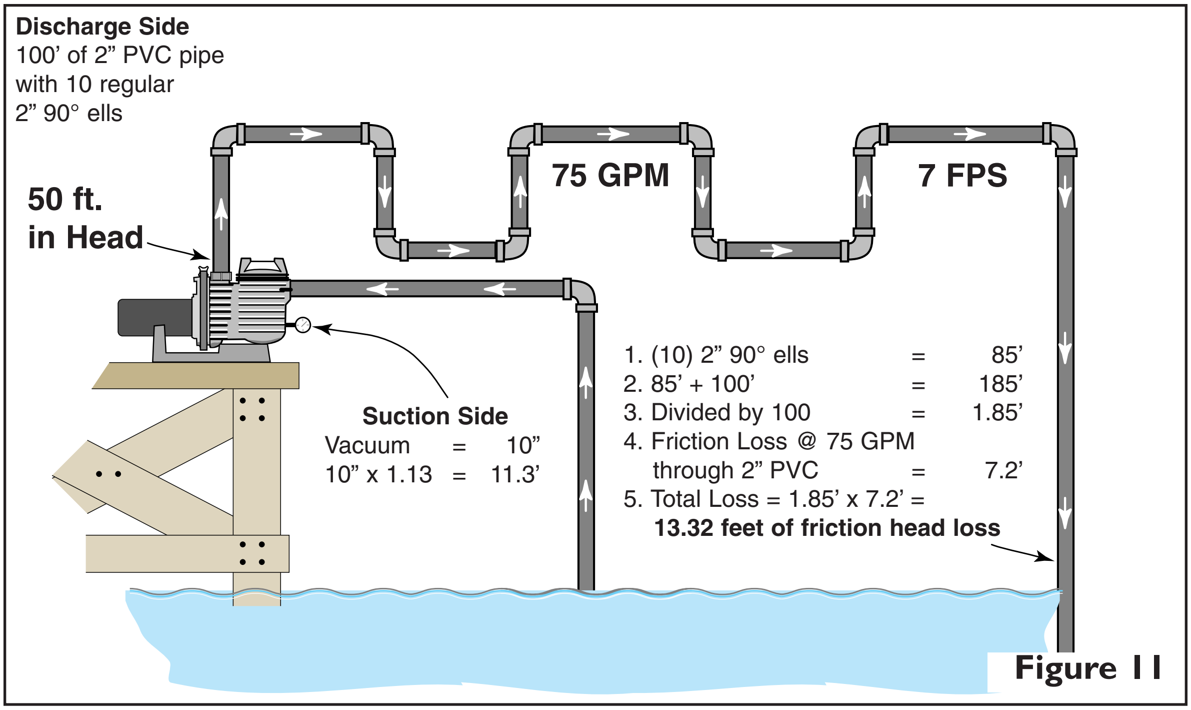


Figure 11

Spa - Gallons Per Minute And Turnover Rates

Since we usually deal with a small volume of water, the gallons per minute for the turnover rate is not normally calculated. However, commercial installations may require 15 minute turnovers. The calculation is the same as for a swimming pool.

Gallons/15 minutes = GPM.

Example:

A 30 minute turnover for a 400 gallon spa is 13.4 GPM. A 1 hour turnover for a 600 gallon spa is 10 GPM. Calculate the GPM for the following spas:

1,000 gallons with a 30 minute turnover rate:

________GPM.

800 Gallons with a 1½ hour turnover rate:

________GPM.

Spa Jets - Gallons Per Minute

Spa jets are the main factor in calculating the necessary gallons per minute. In the old days, we could figure 1/4 HP per jet. At that time, most jets required 20 GPM each. With improvements in jet design and pump performance, we must know the jet’s required GPM.

If the jet is rated at 15 GPM and there are 6 of them, we simply multiply the two together to get the gallons per minute (15 GPM x 6 = 90 GPM)

Because of the many different types of jets available on the market today, it is a good idea to consult with the jet manufacturer before calculating the necessary GPM required for the system.

Calculate Friction Head Loss

Figure 11 shows a short plumbing section on the discharge side of the pump.

There is 100 ft. of 2” PVC pipe with 10 - 2” regular 90° ells, flowing 75 gallons per minute.

The procedure for calculating the head loss in the above plumbing layout is as follows: (Refer to Pages 29, 36, and 37 for conversion charts in the (Charts and Tables).

1. Convert the 2” 90 ells to equivalent length of pipe.
2. Add the equivalent length of pipe to the existing length of pipe.
3. Divide the total equivalent length of pipe by 100.
4. Find the friction loss for 75 GPM through 2”pipe.
5. Multiply the friction head loss times the equivalent length of pipe to get the total friction head loss.

SUCTION SIDE PLUMBING

Skimmer Line
40’ 2” PVC Pipe
3 2” 90° Ells
1 2” Gate Valve
1 2” Skimmer

Main Drain Line
65’ 2” PVC Pipe
3 2” 90° Ells
1 2” Gate Valve
2 2” Main Drains
1 2” Branch Flow Tee

Manifold Line
4’ 2” PVC Pipe
1 2” 90° Ell
1 2” Branch Flow Tee

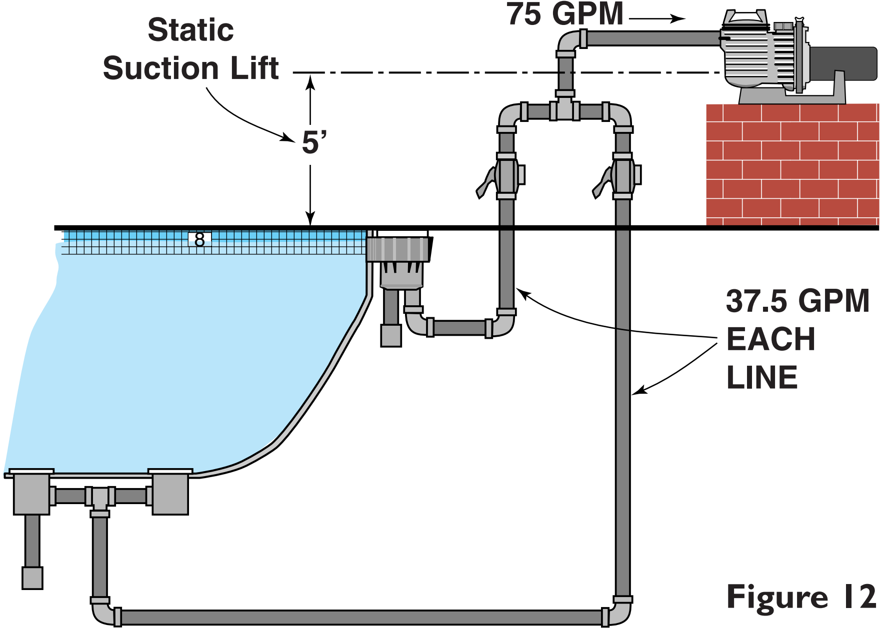


Figure 12

Figure 12 is a typical plumbing layout for the suction side of the circulation system. In this example the Skimmer and Main Drain have separate lines manifolded together into the suction side of the pump.

Procedures for Calculating the Head Loss:

(Refer to Charts on Pages 29, 36, and 37 of the Charts and Tables).

Skimmer Line:

1. Convert the fittings to equivalent length of pipe.
3 - 2″ Reg. 90° Ells = 3 x 8.5 = 25.5′
1 - 2″ Gate Valve = 1.5′
Total equivalent length of pipe = 27.0′

2. Add equivalent length of pipe to the actual pipe length.
Equivalent length of pipe = 27.0′
Length of 2″ pipe = 40.0′
Total pipe length = 67.0′

3. Convert total pipe length to 100′ length.
67.0′ / 100 = .67′

4. Calculate the Friction Head Loss in the Skimmer Line
.67′ pipe length x 2.35 = 1.57′
1 - 2″ Skimmer @ 37.5 GPM = 1.75′
Total Friction Head Loss = 3.32′

Main Drain Line:

1. Convert the fittings to equivalent length of pipe.
1 - 2″ Branch Flow Tee = 12.00′
3 - 2″ Reg. 90° Ell = 3 x 8.5 = 25.50′
1 - 2″ Gate Valve = 1.50′
Total equivalent length of pipe = 39.00′

2. Add equivalent length of pipe to actual pipe length.
Equivalent length of pipe = 39.00′
Length of 2″ pipe = 65.00′
Total pipe length = 104.00′

3. Convert total pipe length to 100′ length.
104.00′ / 100 = 1.04′

4. Calculate the Friction Head Loss in the Main Drain Line.
1.04′ pipe length x 2.35 = 2.44′
2 - 2″ M.D. @ 37.5 GPM = 2.00′
Total Friction Head Loss = 4.44′

Manifold Line:

1. Convert the fittings to equivalent length of pipe.
1 - 2″ Regular 90° Ell = 8.50′
1 - 2″ Branch Flow Tee = 12.00′
Total equivalent length of pipe = 20.50′

2. Add equivalent length of pipe to the actual pipe length.
Equivalent length of pipe = 20.50′
Length of 2″ pipe = 4.00′
Total pipe length = 24.50′

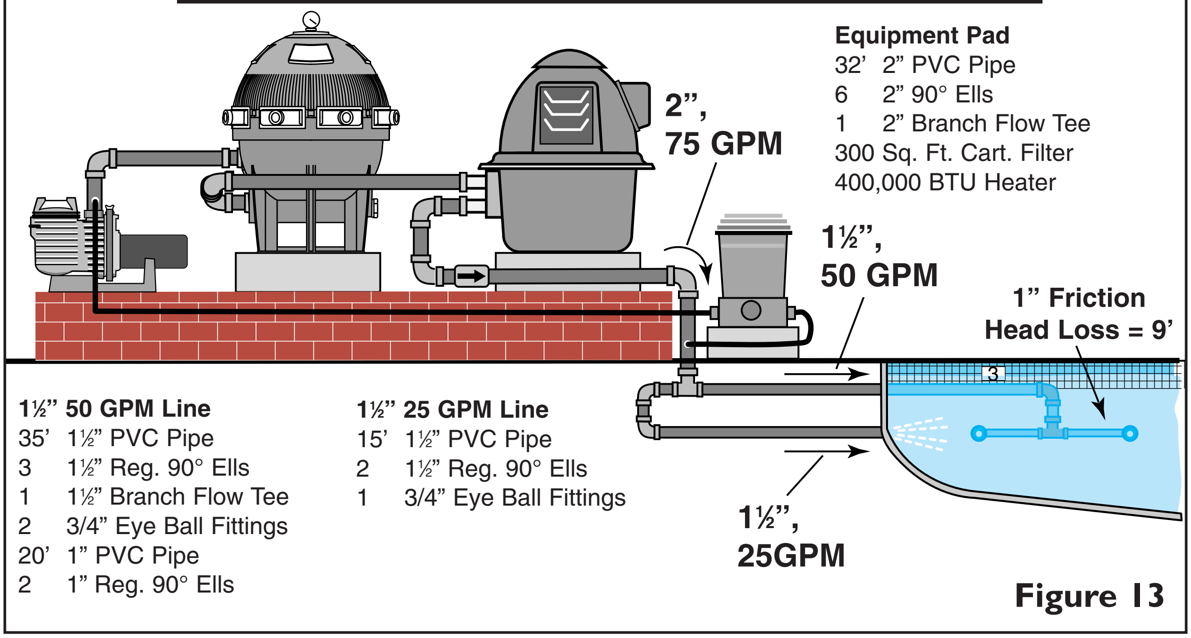
3. Convert total pipe length to 100′ length.
24.50′ / 100 = .25′

4. Calculate the Friction Head Loss in the Manifold Line.
.25′ pipe length x 7.17 = 1.79′
Total Friction Head Loss = 1.79′

Suction Side Head Loss:

Skimmer Line = 3.32′
Main Drain Line = 4.44′
Manifold Line = 1.79′
Static Suction Lift = 5.00′
Total Suction Head Loss = 14.55′

FRICTION HEAD LOSS - RETURN SIDE OF PUMP



Equipment Pad
32' 2" PVC Pipe
6 2" 90° Ells
1 2" Branch Flow Tee
300 Sq. Ft. Cart. Filter
400,000 BTU Heater

1½" 50 GPM Line
35' 1½" PVC Pipe
3 1½" Reg. 90° Ells
1 1½" Branch Flow Tee
2 3/4" Eye Ball Fittings
20' 1" PVC Pipe
2 1" Reg. 90° Ells

1½" 25 GPM Line
15' 1½" PVC Pipe
2 1½" Reg. 90° Ells
1 3/4" Eye Ball Fittings

Figure 13

Figure 13 is a typical plumbing layout for multiple return lines. One 2" line Teed into two 1½" lines, one with a single return fitting, the other with two return fittings.

Procedures for Calculating the Head Loss:

(Refer to Charts on Pages 29, 36, and 37 of the Charts and Tables).

Equipment Pad:

1. Convert the fittings to equivalent length of pipe.
6 - 2" Reg. 90° Ells = 6 x ____ = ____
1 - 2" Branch Flow Tee = ____
Total equivalent length of pipe = ____
2. Add equivalent length of pipe to the actual pipe length.
Equivalent length of pipe = ____
Length of 2" pipe = ____
Total pipe length = ____
3. Convert total pipe length to 100' length.
Total pipe length ____ / 100 = ____
4. Calculate the Friction Head Loss in the equipment pad plumbing.
100' pipe length ____ x ____ = ____
5. Filter Head Loss = ____
6. Heater Head Loss = ____
7. **Total Equipment Pad Head Loss** = ____

1½" 50 GPM Line:

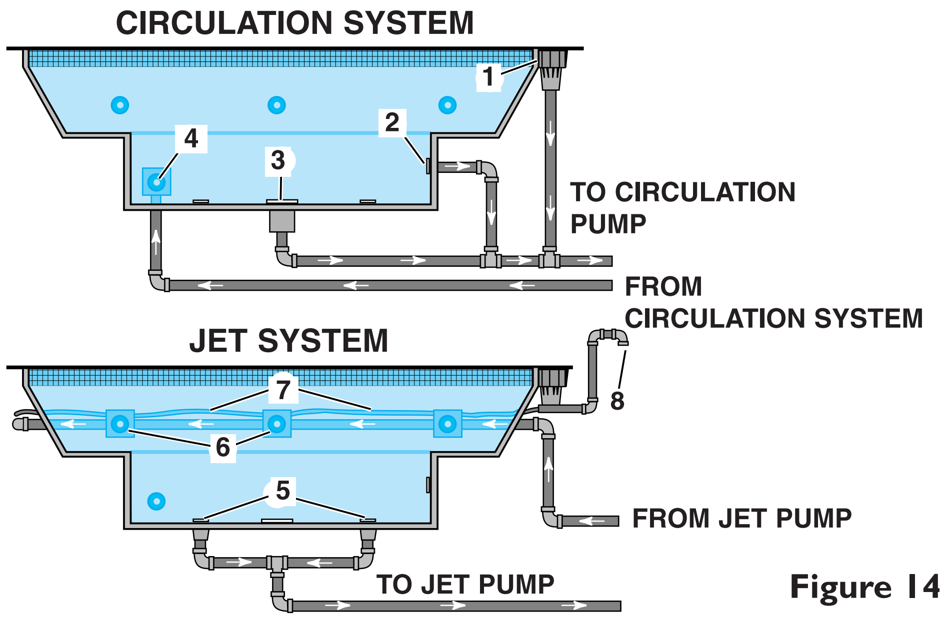
1. Convert the fittings to equivalent length of pipe.
1 - 1½" Reg. 90° Ell = ____
1 - 1½" Branch Flow Tee = ____
Total equivalent length of pipe = ____
2. Add equivalent length of pipe to the actual pipe length.
Equivalent length of pipe = ____
Length of 1½" pipe = ____
Total pipe length = ____
3. Convert total pipe length to 100' length.
Total pipe length ____ / 100 = ____
4. Calculate the Friction Head Loss in the 1½" 50 GPM line.
100' pipe length ____ x ____ = ____
5. Friction Head Loss in 1" line = 9.0"
(Including the Branch Flow Tee)
6. Exit Loss 3/4" @ 25 GPM = ____
7. **Total Friction Head Loss** = ____

1½" 25 GPM Line:

1. Convert the fittings to equivalent length of pipe.
2 - 1½" Reg. 90° Ells = 2 x ____ = ____
2. Add equivalent length of pipe to the actual pipe length.
Equivalent length of pipe = ____
Length of 1½" pipe = ____
3. Convert total pipe length to 100' length.
Total pipe length ____ / 100 = ____
4. Calculate the Friction Head Loss in the 1½" 25 GPM Line.
100' pipe length ____ x ____ = ____

Return Side Head Loss:

Equipment Pad Head Loss = ____
50 GPM Line Head Loss = ____
25 GPM Line Head Loss = ____
Total Return Side Head Loss = ____
Total Suction Side Head Loss = ____
Total Circulation System Head Loss = ____



TWO PUMP SPA SYSTEM

Figure 14

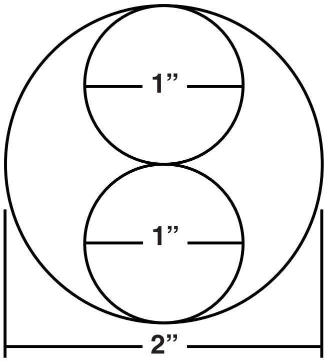
Circulation System Plumbing:

1. **Surface Skimmer** - Normal flow is a minimum of 25 gpm. The maximum flow is 50 gpm. Some skimmers are designed so that the Hair Lint Basket can be removed through the throat of the skimmer. Others are designed with a built in Cartridge Filter. These are usually portable units that have a built in pumping, filtering and heating system.
2. **Auxiliary Suction** - Designed to offer a separate source of water for the pump in case the flow through the Main Drain or Skimmer become restricted. Auxiliary Suction Fitting should be IAPMO approved.
3. **Main Drain** - Located at the lowest point of the spa. It is designed to collect the heavier dirt particles that are passed on to the filter system. The Main Drain Cover should be IAPMO approved. Always secure the cover with a screw.
4. **Deep Heat Return** - By injecting heated water at the lowest point possible, you get a better distribution of the heat. This will make the heat up time more efficient and less costly.

Jet System Plumbing:

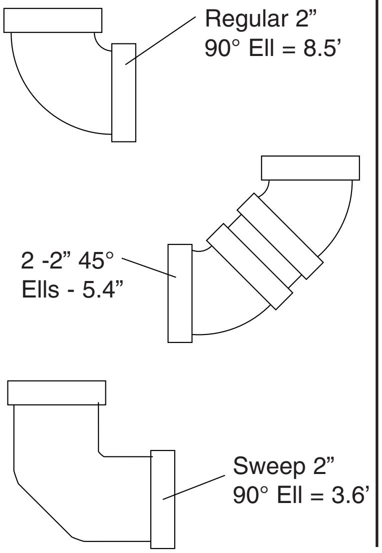
5. **Dual Main Drains** - Designed for safety. By drawing the water from two separate sources, the spa is safer from possible entrapment and entanglement. Dual Main Drains also cut down on the possibility of eddies forming.
6. **Spa Jets** - Designed to add velocity to the water flow and draw air from the atmosphere or a Mechanical Blower. The addition of air can add as much as 50% to the volume of the jet stream. There are some specialized jets on the market that give a messaging action. The plumbing should be “Looped” for equal jet pressure.
7. **Air Line** - Usually a Flex type pipe. This line should be “Looped” for equal pressure and better distribution of the air.
8. **Air Intake** - Source for air for the spa jets. Can be connected to a Mechanical Blower for even better action. Some spas have a separate air line for each jet for individual adjustments.

PLUMBING AND SAFETY TIPS



Multiple Lines vs. One Line
2 - 1” pipes can only handle 1/2 the volume of a 2” pipe.

Equivalent Length of Pipe



Pipe Sizing Per Horsepower of Pump
(Self Priming @ 60’)

	25’ Run		50’ Run		Over 50’	
H.P.	**Suc.**	**Ret.**	**Suc.**	**Ret.**	**Suc.**	**Ret.**
1/2	1.5”	1.5”	1.5”	1.5”	2”	1.5”
3/4	2”	1.5”	2”	2”	2”	2”
1	2”	2”	2.5”	2”	2.5”	2.5”
1.5	2.5”	2.5”	3”	2.5”	3”	3”
2	2.5”	2.5”	3”	3”	3”	3”
3	3”	3”	3”	3”	4”	3”
5	4”	3”	4”	4”	4”	4”
7.5	6”	6”	6”	6”	6”	6”
10	6”	6”	6”	6”	6”	6”
15	6”	6”	8”	6”	8”	8”
20	8”	8”	8”	8”	8”	8”

Figure 15

Plumbing & Safety Tips:

1. **Long Plumbing Runs** - Always use the correct size pump and compensate for extended pipe runs with larger pipe sizes. Increasing pump H.P. to try to overcome long plumbing runs will make the system less efficient.
2. **Dual Suctions** - Dual suctions should be plumbed into all pools and spas to prevent body or hair entrapment. Use only IAPMO approved fittings for suction use.

   Areas to also consider for dual suctions are any shallow body of water, such as a spa, fountain, or a wading pool. Dual suctions in shallow bodies of water will cut down on the possibility of “Eddies” forming. Eddies can cause damage to the pump and make the system less efficient.

   In commercial Skimmer applications it is a good idea to use “Dual Auxiliary Suction Fittings to cut down on the velocity of the water when the Auxiliary line is open.
3. **Suction Connections for Suction Side Cleaners** - Side wall connections for the Suction Side Cleaners should have a solid connection or Self Closing Sealing Covers should be used on designated Suction Cleaner connection, for safety. Friction connections may come loose exposing a single suction source that could trap someone.
4. **Pressure Testing Systems** - Make sure to evacuate all of the air out of the system as the pressure builds. Trapped air will compress and powerfully propel a filter lid that has an improperly installed clamp. Never pressure test with pressures above 25 psi.
5. **If you can’t “LOOP” your return fittings**, tie into a center point with an equal number on each side of tee. Then use a tee on the last return instead of a 90°ell. Extend each line about 6” to a foot past the tee and cap the ends. The back pressure from the capped end will help the last fittings in the line to work better. It’s not as good a looping, but it helps.

Friction/Flow Chart For Schedule 40 Rigid PVC Pipe

Friction Loss of Water in Feet per 100 Feet Length of Pipe

Based on Williams & Hazen Formula Using Constant 150. Sizes of Standard Pipe in Inches.

U.S. Gals. per Min.	¾" Pipe		1" Pipe		1¼" Pipe		1½" Pipe		2" Pipe		2½" Pipe		3" Pipe		U.S. Gals. per Min.
	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	Vel. Ft. per Sec.	Loss in Feet	
1	.60	.25	.37	.07	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**1**
2	1.20	.90	.74	.28	.43	.07	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**2**
3	1.80	1.92	1.11	.60	.64	.16	.47	.07	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**3**
4	2.41	3.28	1.48	1.02	.86	.25	.63	.12	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**4**
5	3.01	5.8	1.86	1.52	1.07	.39	.79	.18	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**5**
6	3.61	7.0	2.33	2.15	1.29	.55	.95	.25	.57	.07	. . . .	. . . .	. . . .	. . . .	**6**
8	4.81	11.8	2.97	3.6	1.72	.97	1.25	.46	.76	.14	.54	.05	. . . .	. . . .	**8**
10	6.02	17.9	3.71	5.5	2.15	1.46	1.58	.69	.96	.21	.67	.09	. . . .	. . . .	**10**
15	9.02	37.8	5.57	11.7	3.22	3.07	2.36	1.45	1.43	.44	1.01	.18	.65	.07	**15**
20	. . . .	. . . .	7.42	19.9	4.29	4.2	3.15	2.47	1.91	.74	1.34	.30	.87	.12	**20**
25	. . . .	. . . .	9.28	30.0	5.36	7.9	3.94	3.8	2.39	1.11	1.67	.46	1.08	.16	**25**
30	. . . .	. . . .	11.14	42.0	6.43	11.1	4.73	5.2	2.87	1.55	2.01	.65	1.30	.23	**30**
35	. . . .	. . . .	. . . .	. . . .	7.51	14.7	5.52	7.0	3.35	2.06	2.35	.88	1.52	.30	**35**
40	. . . .	. . . .	. . . .	. . . .	8.58	18.9	6.30	8.9	3.82	2.63	2.64	1.11	1.73	.39	**40**
45	. . . .	. . . .	. . . .	. . . .	9.65	23.5	7.09	11.1	4.30	3.28	3.01	1.39	1.95	.48	**45**
50	. . . .	. . . .	. . . .	. . . .	10.72	28.5	7.88	13.5	4.78	4.0	3.35	1.69	2.17	.58	**50**
60	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	9.46	18.9	5.74	5.6	4.02	2.36	2.60	.81	**60**
70	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	11.03	25.1	6.69	7.4	4.69	3.14	3.04	1.09	**70**
80	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	7.65	9.5	5.35	4.0	3.47	1.39	**80**
90	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	8.60	11.8	6.03	5.0	3.91	1.73	**90**
100	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	9.56	14.4	6.70	6.1	4.34	2.10	**100**
125	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	11.95	21.8	8.38	9.2	5.42	3.19	**125**
150	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	10.05	12.8	6.51	4.5	**150**
175	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	7.59	5.9	**175**
200	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	8.68	7.9	**200**
225	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	9.76	9.4	**225**
250	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	10.85	11.5	**250**
275	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**275**
300	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**300**
325	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**325**

Normal safe operating selection; ☐ Suction piping; ☐ Discharge or pressure piping.

Note: Where long pipe runs are encountered, make selection in minimum head loss range.

Head Loss Charts

Component	GPM	Head Loss (Ft.)	Component	GPM	Head Loss (Ft.)
Main drain 1-1/2" Outlet	20	0.5	Skimmer 1-1/2"	20	1.0
	30	1.0		30	2.0
	40	1.5		40	3.0
	50	2.0		50	4.0
	60	2.5		60	5.5
Main drain 2" Outlet	40	1.0	Skimmer 2" Outlet	20	0.5
	50	1.5		30	1.0
	60	2.0		40	2.0
	70	3.0		50	3.0
	80	4.0		60	4.0
Heater	–	7.0 Average		70	5.0
				80	6.0
Backwash Valves					
1-1/2" Push/Pull	50	6.0	1-1/2" Multiport	50	5.0
	75	13.5		75	10.0
2" Push/Pull	75	7.0	2" Multiport	75	3.5
	120	17.6		100	6.0
				120	8.5

Cartridge Filters	GPM (.75)	Head Loss (Ft.)	GPM (.375)	Head Loss (Ft.)
25 sq. ft.	18.75	1.1	9.38	7.0 Average
35 sq. ft.	26.25	2.0	13.13	7.0 Average
50 sq. ft.	37.50	4.3	18.75	7.0 Average
70 sq. ft.	52.50	7.5	26.25	7.0 Average
75 sq. ft.	56.25	8.0	28.13	7.0 Average
100 sq. ft.	75.00	17.5	37.50	7.0 Average
135 sq. ft.	101.25	28.0	50.63	7.0 Average

Sand Filters	GPM (20)	Head Loss (Ft.)	GPM (15)	Head Loss (Ft.)
14" 1.05 sq. ft.	21.0	10 (est.)	15.8	7.0 Average
16" 1.41 sq. ft.	28.2	12 (est.)	21.2	7.0 Average
18" 1.80 sq. ft.	36.0	14 (est.)	27.0	7.0 Average
20" 2.20 sq. ft.	44.0	16	33.0	7.0 Average
22" 2.66 sq. ft.	53.2	18 (est.)	39.9	7.0 Average
24" 3.10 sq. ft.	63.0	25	46.5	7.0 Average
30" 4.90 sq. ft.	98.0	17	73.5	7.0 Average
36" 7.10 sq. ft.	142.0	24 (est.)	106.5	7.0 Average

Modular Media Filters	GPM	Head Loss (Ft.)	GPM (.375)	Head Loss (Ft.)
100 sq. ft. "Mini Mods."	75	6.0	38	1.5
125 sq. ft. "Mini Mods."	94	9.0	47	2.5
150 sq. ft. "Mini Mods."	113	12.0	56	3.5
175 sq. ft. "Mini Mods."	131	16.0	66	4.5
200 sq. ft. "Mini Mods."	150	20.0	75	6.0
300 sq. ft. "Mini Mods."	150	20.0	113	13.0

Modular Media Filters	GPM (NSF)	Head Loss (Ft.)
300 sq. ft. - System3	100	3.0
400 sq. ft. - System3	115	4.6
450 sq. ft. - System3	124	5.5
500 sq. ft. - System3	130	6.3

Modular D.E. Filters	GPM (1.5)	Head Loss (Ft.)	GPM (NSF)	Head Loss (Ft.)
30 sq. ft.	45	3.8	60	6.5
36 sq. ft.	54	5.5	70	9.0
60 sq. ft.	90	7.0	120	13.0
72 sq. ft.	108	10.0	144	18.0

Exit Loss Charts

3/8” (.375 ID)

GPM	Velocity FPS	Exit Head (Ft.)
1	2.91	.13
2	5.81	.53
3	8.71	1.18
4	11.62	2.10
5	14.53	3.28
6	17.43	4.72
7	20.34	6.43
8	23.24	8.40
9	26.15	10.63
10	29.05	13.12

1/2” (.50 ID)

GPM	Velocity FPS	Exit Head (Ft.)
5	8.17	1.04
6	9.80	1.49
7	11.44	2.03
8	13.07	2.66
9	14.71	3.36
10	16.34	4.15
11	17.98	5.02
12	19.61	5.98
13	21.24	7.02
14	22.88	8.14
15	24.51	9.34
16	26.15	10.63
17	27.78	12.00
18	29.41	13.45
19	31.05	14.99
20	32.68	16.61

3/4” (.75 ID)

GPM	Velocity FPS	Exit Head (Ft.)
5	3.63	.21
6	4.36	.30
7	5.08	.41
8	5.81	.53
9	6.54	.67
10	7.27	.82
11	7.99	.99
12	8.72	1.18
13	9.44	1.39
14	10.17	1.61
15	10.89	1.85
16	11.62	2.10
17	12.35	2.37
18	13.07	2.66
19	13.80	2.96
20	14.53	3.28
21	15.25	3.62
22	15.98	3.97
23	16.70	4.34
24	17.43	4.72
25	18.16	5.13
26	18.88	5.54
27	19.60	5.98
28	20.34	6.43
29	21.06	6.90
30	21.79	7.38

7/8” (.875 ID)

GPM	Velocity FPS	Exit Head (Ft.)
10	5.34	.44
11	5.87	.54
12	6.40	.64
13	6.94	.75
14	7.47	.87
15	8.00	1.00
16	8.54	1.13
17	9.07	1.28
18	9.60	1.43
19	10.14	1.60
20	10.67	1.77
21	11.21	1.95
22	11.74	2.14
23	12.27	2.34
24	12.81	2.55
25	13.34	2.77
26	13.87	2.99
27	14.41	3.23
28	14.94	3.47
29	15.47	3.72
30	16.01	3.98
31	16.54	4.25
32	17.08	4.53
33	17.61	4.82
34	18.14	5.11
35	18.68	5.42
36	19.21	5.74
37	19.74	6.06
38	20.28	6.39
39	20.81	6.73
40	21.34	7.08

1.0” (1.0 ID)

GPM	Velocity FPS	Exit Head (Ft.)	GPM	Velocity FPS	Exit Head (Ft.)	GPM	Velocity FPS	Exit Head (Ft.)
15	6.13	.58	27	11.03	1.89	39	15.93	3.95
16	6.54	.66	28	11.44	2.03	40	16.34	4.15
17	6.95	.75	29	11.85	2.18	41	16.75	4.36
18	7.35	.84	30	12.26	2.34	42	17.16	4.58
19	7.76	.94	31	12.66	2.49	43	17.57	4.80
20	8.17	1.04	32	13.07	2.66	44	17.98	5.02
21	8.58	1.14	33	13.48	2.83	45	18.38	5.25
22	8.99	1.26	34	13.89	3.00	46	18.79	5.49
23	9.40	1.37	35	14.30	3.18	47	19.20	5.73
24	9.81	1.50	36	14.71	3.36	48	19.61	5.98
25	10.21	1.62	37	15.12	3.55	49	20.02	6.23
26	10.62	1.75	38	15.52	3.75	50	20.43	6.49

Friction Loss Created by Pipe Fittings

The friction created by fittings is expressed as the equivalent length of straight pipe. For example, the loss through a 1" regular 90° Ell is equal to that created by 5.2 feet of straight 1" steel pipe. Determine total friction by combining fitting loss with pipe loss.

Equivalent Length of Straight Pipe for Various Fittings. Turbulent Flow Only.

Fittings			Pipe Size															
			¼	⅜	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12
Regular 90° Ell	Screwed	Steel	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0					
		C.I.										9.0	11.0					
	Flanged	Steel			.92	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3	8.9	12.0	14.0	17.0
		C.I.										3.6	4.8		7.2	9.8	12.0	15.0
Long Radius 90° Ell	Screwed	Steel	1.5	2.0	2.2	2.3	2.7	3.2	3.4	3.6	3.6	4.0	4.6					
		C.I.										3.3	3.7					
	Flanged	Steel			1.1	1.3	1.6	2.0	2.3	2.7	2.9	3.4	4.2	5.0	5.7	7.0	8.0	9.0
		C.I.										2.8	3.4		4.7	5.7	6.8	7.8
Regular 45° Ell	Screwed	Steel	.34	.52	.71	.92	1.3	1.7	2.1	2.7	3.2	4.0	5.5					
		C.I.										3.3	4.5					
	Flanged	Steel			.45	.59	.81	1.1	1.3	1.7	2.0	2.6	3.5	4.5	5.6	7.7	9.0	11.0
		C.I.										2.1	2.9		4.5	6.3	8.1	9.7
Tee-Line Flow	Screwed	Steel	.79	1.2	1.7	2.4	3.2	4.6	5.6	7.7	9.3	12.0	17.0					
		C.I.										9.9	14.0					
	Flanged	Steel			.69	.82	1.0	1.3	1.5	1.8	1.9	2.2	2.8	3.3	3.8	4.7	5.2	6.0
		C.I.										1.9	2.2		2.1	3.9	4.6	5.2
Tee-Branch Flow	Screwed	Steel	2.4	3.5	4.2	5.3	6.6	8.7	9.9	12.0	13.0	17.0	21.0					
		C.I.										14.0	17.0					
	Flanged	Steel			2.0	2.6	3.3	4.4	5.2	6.6	7.5	9.4	12.0	15.0	18.0	24.0	30.0	34.0
		C.I.										7.7	10.0		15.0	20.0	25.0	30.0
180° Return Bend	Screwed	Steel	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0					
		C.I.										9.0	11.0					
	Regular Flanged	Steel			.92	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3	8.9	12.0	14.0	17.0
		C.I.										3.6	4.8		7.2	9.8	12.0	15.0
	Long. Rad. Flanged	Steel			1.1	1.3	1.6	2.0	2.3	2.7	2.9	3.4	4.2	5.0	5.7	7.0	8.0	9.0
		C.I.										2.8	3.4		4.7	5.7	6.8	7.8

Friction Loss Created by Pipe Fittings

The friction created by fittings is expressed as the equivalent length of straight pipe. For example, the loss through a 1" regular 90° Ell is equal to that created by 5.2 feet of straight 1" steel pipe. Determine total friction by combining fitting loss with pipe loss.

Equivalent Length of Straight Pipe for Various Fittings. Turbulent Flow Only.

Fittings			Pipe Size															
			¼	⅜	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10	12
Globe Valve	Screwed	Steel	21.0	22.0	22.0	24.0	29.0	37.0	42.0	54.0	62.0	79.0	110.0					
		C.I.										65.0	86.0					
	Flanged	Steel			38.0	40.0	45.0	54.0	59.0	70.0	77.0	94.0	120.0	150.0	190.0	260.0	310.0	390.0
		C.I.										77.0	99.0		150.0	210.0	270.0	330.0
Gate Valve	Screwed	Steel	.32	.45	.56	.67	.84	1.1	1.2	1.5	1.7	1.9	2.5					
		C.I.										1.6	2.0					
	Flanged	Steel								2.6	2.7	2.8	2.9	3.1	3.2	3.2	3.2	3.2
		C.I.										2.3	2.4		2.6	2.7	2.8	.29
Angle Valve	Screwed	Steel	12.8	15.0	15.0	15.0	17.0	18.0	18.0	18.0	18.0	18.0	18.0					
		C.I.										15.0	15.0					
	Flanged	Steel			15.0	15.0	17.0	18.0	18.0	21.0	22.0	28.0	38.0	50.0	63.0	90.0	120.0	140.0
		C.I.										23.0	31.0		52.0	74.0	98.0	120.0
Swing Check Valve	Screwed	Steel	7.2	7.3	8.0	8.8	11.0	13.0	15.0	19.0	22.0	27.0	38.0					
		C.I.										22.0	31.0					
	Flanged	Steel			3.8	5.3	7.2	10.0	12.0	17.0	21.0	27.0	38.0	50.0	63.0	90.0	120.0	140.0
		C.I.										22.0	31.0		52.0	74.0	98.0	120.0
Coupling or Union	Screwed	Steel	.14	.18	.21	.24	.29	.36	.39	.45	.47	.53	.65					
		C.I.										.44	.52					
	Bell Mouth Inlet	Steel	.04	.07	.10	.13	.18	.26	.31	.43	.52	.67	.95	1.3	1.6	2.3	2.9	3.5
		C.I.										.55	.77		1.3	1.9	2.4	3.0
	Square Mouth Inlet	Steel	.44	.68	.96	1.3	1.8	2.6	3.1	4.3	5.2	6.7	9.5	13.0	16.0	23.0	29.0	35.0
		C.I.										5.5	7.7		13.0	19.0	24.0	30.0
Re-Entrapment Pipe		Steel	.88	1.4	1.9	2.6	3.6	5.1	6.2	8.5	10.0	13.0	19.0	25.0	32.0	45.0	58.0	70.0
		C.I.										11.0	15.0		26.0	37.0	49.0	61.0
Sudden Enlargement			$b = \frac{(V_1 - V_2)^2}{2g}$ Feet of Fluid; if $V_2 = 0$ $b = \frac{V_1^2}{2g}$ Feet of Fluid															

Calculating Turn Over Rates

New Pool or Spa – Divide the Pool or Spa gallons by the number of minutes the filter system is designed to operate in a single day.

Example:

A 6 hour turn over is equal to 360 minutes.

A 8 hour turn over is equal to 480 minutes.

A 30 minute turn over is the divider.

50,000 gallon pool with a 6 hour turn over rate

50,000 / 360 = 139 gpm

25,000 gallon pool with an 8 hour turn over rate

25,000 / 480 = 52 gpm

1,000 gallon spa with a 30 minute turn over rate

1,000 / 30 = 33 gpm

Existing Pool or Spa – Determine the maximum flow rate from the existing pipe sizes (See Pipe Sizing Chart in the next column).

Example:

1-1/2″ pipe = 44 gpm, 2″ = 75 gpm

25,000 gallon pool with 1-1/2″ pipe

25,000 / 1-1/2″ Flow Rate x 60 = Turn Over Rate

25,000 / 44 x 60 = 9.5 hours

Filter Sizing

Pool or Spa – Divide the pump gallons per minute by the recommended flow rate for the filter.

Example:

D.E. = 1.5 gpm per sq. ft. of filter area.

80 gpm / 1.5 = 53

Sand = 15 gpm per sq. ft. of filter area.

74 gpm / 15 = 4.9

Cartridge = .375 gpm per sq. ft. of filter area.

50 gpm / .375 = 133

Pipe Sizing Chart - Schedule 40 PVC

Pipe Size	7 fps	8 fps	10 fps
3/4″	12 gpm	14 gpm	17 gpm
1″	18 gpm	22 gpm	28 gpm
1-1/4″	33 gpm	37 gpm	47 gpm
1-1/2″	44 gpm	52 gpm	62 gpm
2″	75 gpm	85 gpm	110 gpm
2-1/2″	110 gpm	118 gpm	125 gpm
3″	160 gpm	185 gpm	235 gpm
4″	275 gpm	310 gpm	395 gpm
6″	540 gpm	725 gpm	850 gpm

Calculating Head Loss for an Existing Pool or Spa

Pressure Gauge x 2.31 = Head Loss plus

Vacuum Gauge x 1.13 = Head Loss equals

Total System Loss

Example:

Pressure Gauge Reading = 20 lbs.
Vacuum Gauge Reading = 10″

20 lbs. x 2.31 = 46 foot of head
10″ x 1.13 = 11 foot of head

Total System Loss = 57 foot of head

Modular Media Sizing

Size filters based on maximum design flow

Example:

S8M150 - 450 sq. ft. = 125 gpm

500 gpm / 125 = 4 filters

500 gpm / 1800 sq. ft. = .28 flow rate

Calculating Filter Flow Rates

Divide the gallons per minute by the sq. footage of the filter.

Examples:

125 gpm w/83 DE
125 gpm / 83 = 1.5 gpm per sq. ft. of filter area

50 gpm w/ 3.4 Sand
50 gpm / 3.4 = 15 gpm per sq. ft. of filter area

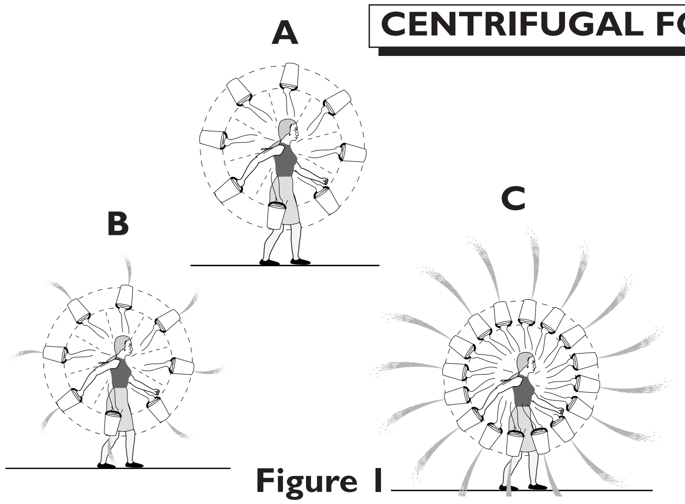


Figure 1

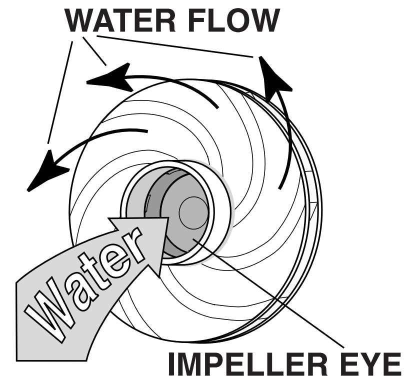


Figure 2

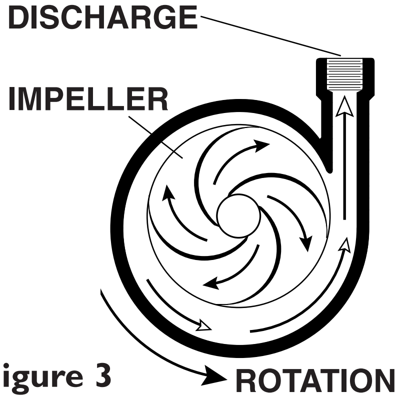


Figure 3

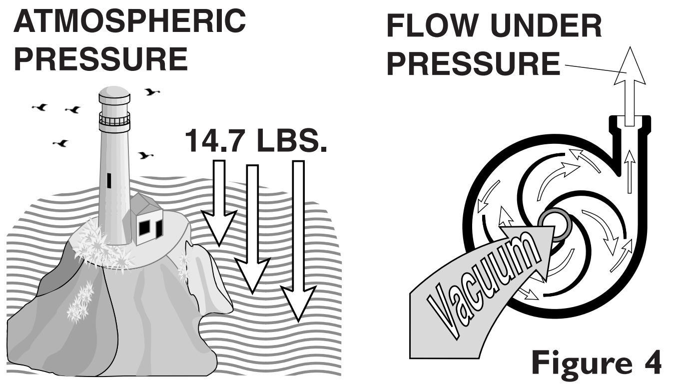


Figure 4

Swimming Pool and Spa Pumps

Pumps used for swimming pools, spas, and water features are classified as centrifugal pumps. A centrifugal pump derives its name from the principal known as centrifugal force. A centrifugal pump, in its most simplified form, consists of two components. One component is stationary and serves as the housing. It is known as a volute. Inside the volute is the rotating component known as the impeller. If the motor is the “work horse” of the pump, the impeller is the “cartwheel” that moves the water along.

The principal of operation can be demonstrated by whirling a bucket full of water. In Figure 1, as the bucket is rotated, the water is held in the bucket by centrifugal force. (A) If we were to punch a hole in the bottom of the bucket, the water would be forced out, again by centrifugal force. (B) If we were to speed up the rotation of the bucket, the water would exit with greater pressure. (C)

This same principal is performed by the impeller of the pump. As water enters the center or “eye” of the impeller, it is forced through the impeller vanes toward the outside edge (Figure 2). The spinning, impelling action of these vanes generates centrifugal force, propelling the water at a greater velocity (Figure 3)

This action imparts kinetic or velocity energy into the water. As the water is propelled to the outer edge of the impeller, there is a reduction in pressure at the eye of the impeller, creating a partial “vacuum. (See Figure 4)

As we learned in the Hydraulic Section, atmospheric pressure is necessary for the pump to perform. The combination of the atmospheric pressure on the surface of the water and the vacuum at the eye of the impeller, causes the water to flow in the “suction pipe” to the pump. (Figure 4)

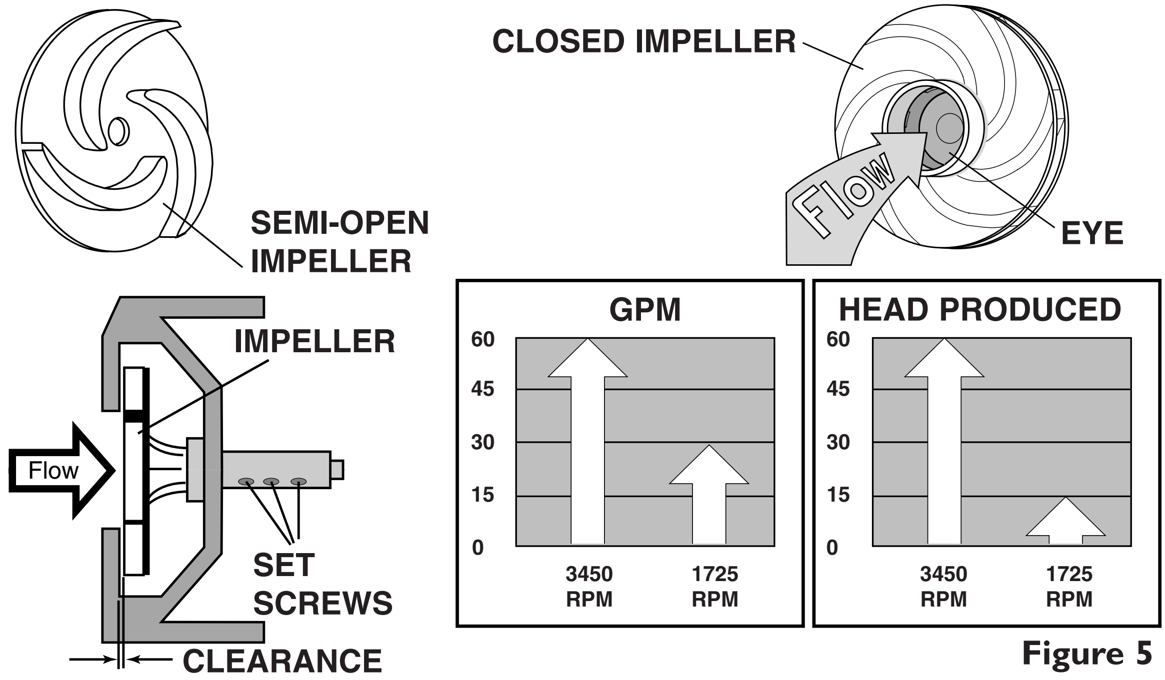


Figure 5

The amount of pressure energy imparted into the water by the impeller is determined in part by the size and design of the impeller. Figure 5 shows there are two types of impellers used in swimming pool, spa, and the water feature pumps: semi-open impeller and closed impellers.

The semi-open impeller has the vanes exposed on the front or receiving side. The back side of the vanes are closed by a shroud. (Top left of Figure 5)

The inner surface of the pump volute serves as the front shroud of the impeller. The efficiency of this design is determined by the clearance between the front of the impeller and the face of the volute surface. (Lower left of Figure 5)

The clearance for a semi-open impeller can usually be adjusted by the set screws on the motor shaft or by the use of shims. This is considered a non-clogging impeller.

A closed impeller is designed to have two shrouds that completely enclose the area of the impeller vane (Upper left of Figure 5) These are called the front and rear shroud. The impeller design requires no adjustment, since the space between the two shrouds is fixed.

The performance of an impeller is affected by another factor. This factor is the speed of its rotation. The speed at which the impeller rotates affects its head and capacity characteristics. The GPM of pump impeller varies in direct proportion to the change in its speed of rotation.

Example:

The capacity of an impeller is 60 GPM at a rotating speed of 3450 RPM. Its capacity would drop to 30 GPM if the speed of rotation was reduced to 1725 RPM. (Lower right Figure 5)

The head or pressure produced by an impeller varies to the square of the change in its speed of rotation.

Example:

If the speed of rotation of an impeller is reduced from 3450 RPM to 1725 RPM, or 50%, the head produced by the impeller would change to the square of that percentage, or a 75% reduction.

If the head produced by an impeller is 60 ft., at a speed of 3450 RPM, the head would drop to 15 ft., if the rotating speed was reduced to 1725 RPM.

Note: The charts in Figure 5, Lower Right, are the basic principals of a 2 speed pump.

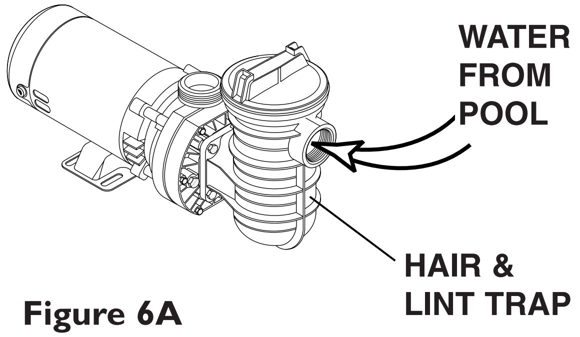


Figure 6A

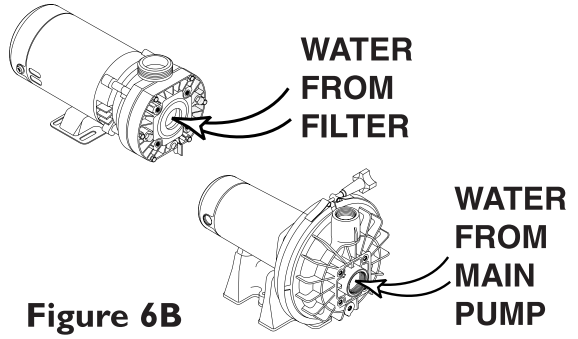


Figure 6B

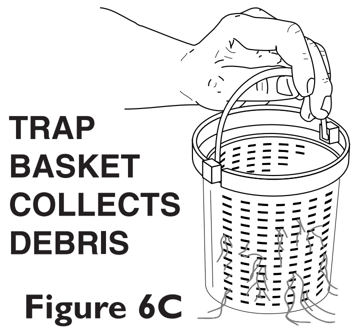


Figure 6C

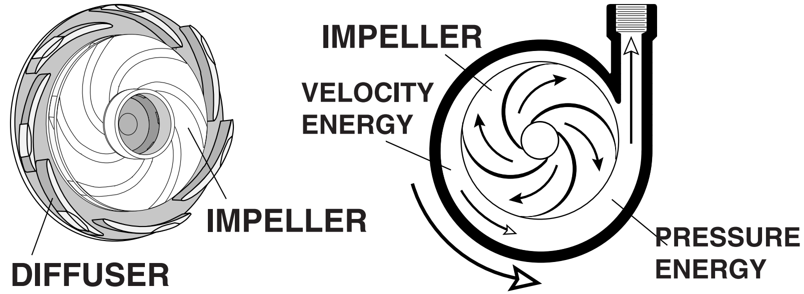


Figure 6D

Water flowing from a swimming pool, spa, or water feature usually will enter the pump through the hair and lint trap. (Figure 6 - A)

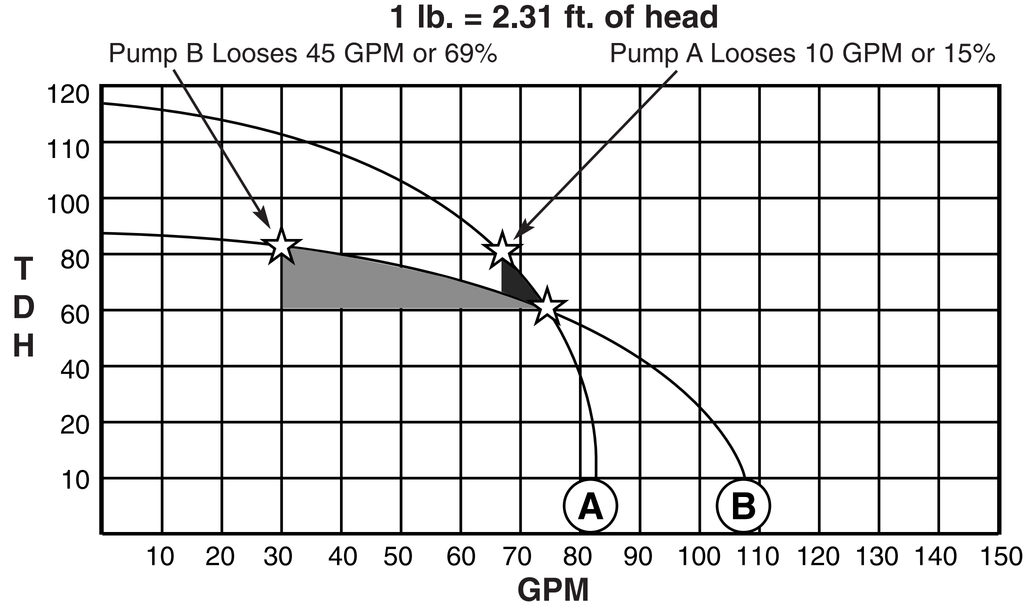
Inside the hair and lint trap is a strainer called the hair lint basket. It is designed to collect trash and debris that could clog the impeller. (Figure 6 - C)

Pumps that are installed with the filter on the suction side usually do not need to have a hair lint trap. The filter acts as the trap, catching the trash and debris. This type of installation is called a "Vacuum Systems" and is usually found on portable spas, and some commercial pools. However, it is not uncommon to find a pump installed without the hair lint trap when used as a booster pump. When used in this manner, it's source of water usually comes from another pump. (Figure 6 - B)

Water flows from the hair and lint trap to the impeller. The impeller discharges it directly in a vaned diffuser or into a volute, depending on the design of the pump.
(Figure 6 - D)

A diffuser consists of a number of vanes which are set around the impeller. As the water is discharged from the impeller, its velocity is very high. As it flows through the diffuser, the vanes help to reduce the speed of flow. As a result, the priming capabilities and the hydraulic efficiencies of a pump are improved.

Other types of centrifugal pumps are designed to permit the volute casing to fully encompass the impeller and flare out into the discharge opening. This allows a gradual reduction in the velocity of the water as it moves from the impeller to the discharge port.



"Both pumps are rated at 60 GPM at 60 Ft. of Head"

Figure 7

Note: When comparing diffuser pumps and volute pumps, remember that each pump was designed with different goals. The diffuser pump can generally prime faster. The volute pump, on the other hand, works well where smaller pump bodies are needed such as portable spas and jetted bathtubs. The volute pump, designed with a semi-open impeller can handle bodies of water that have debris problems, such as pine needles, much better.

Most centrifugal pumps used on filtration systems are classified as high head pumps. However, the real test of a centrifugal pump, is its "head vs. capacity" performance. Most filter manufactures recommend that the pressure in the filter be allowed to rise as much as ten pounds per square inch (psi) above the initial start-up pressure before the filter is cleaned. This rise in pressure affects an increase in the total system head which reduces the GPM of a centrifugal pump. A pressure rise in the filter of ten pounds psi translates to an increase in total head of 23 ft.

1 lb. psi = 2.31 ft. of head

This rise in the resistance of the system affects the pump's performance.

Performance curve B in Figure 7 represents a typical 1 HP medium head pump. Assume the filter media is clean. The total system head is 60 ft. The capacity of pump B at 60 ft. of head is 75 GPM. An increase of 10 psi filter pressure would raise the total system head to 83 ft. This increase of 23 ft. of head causes the capacity of the pump to be reduced to 30 GPM, or a loss of approximately 60% flow.

Performance curve A in Figure 7 represents a typical high head pump. At a total system head of 60 ft., the capacity of this pump is 75 GPM. At a total system head loss of 83 ft., which represents a filter pressure increase of 10 psi, the capacity of this pump declines to only 65 GPM, or a loss of approximately 15% flow.

It is clear that if you have a choice you would use a high head pump on your filtration systems. If a medium head pump is used for a filtration system, it should be cleaned at a 5 lb. increase on the pressure gauge. The best application for a medium head is for systems that have a constant pressure. Spa jets, water falls, fountains, etc. These applications are generally sized at approximately 40 ft. of head. Pump B in Figure 7 will deliver over 90 GPM vs. Pump A, which will give you a little less than 80 GPM.

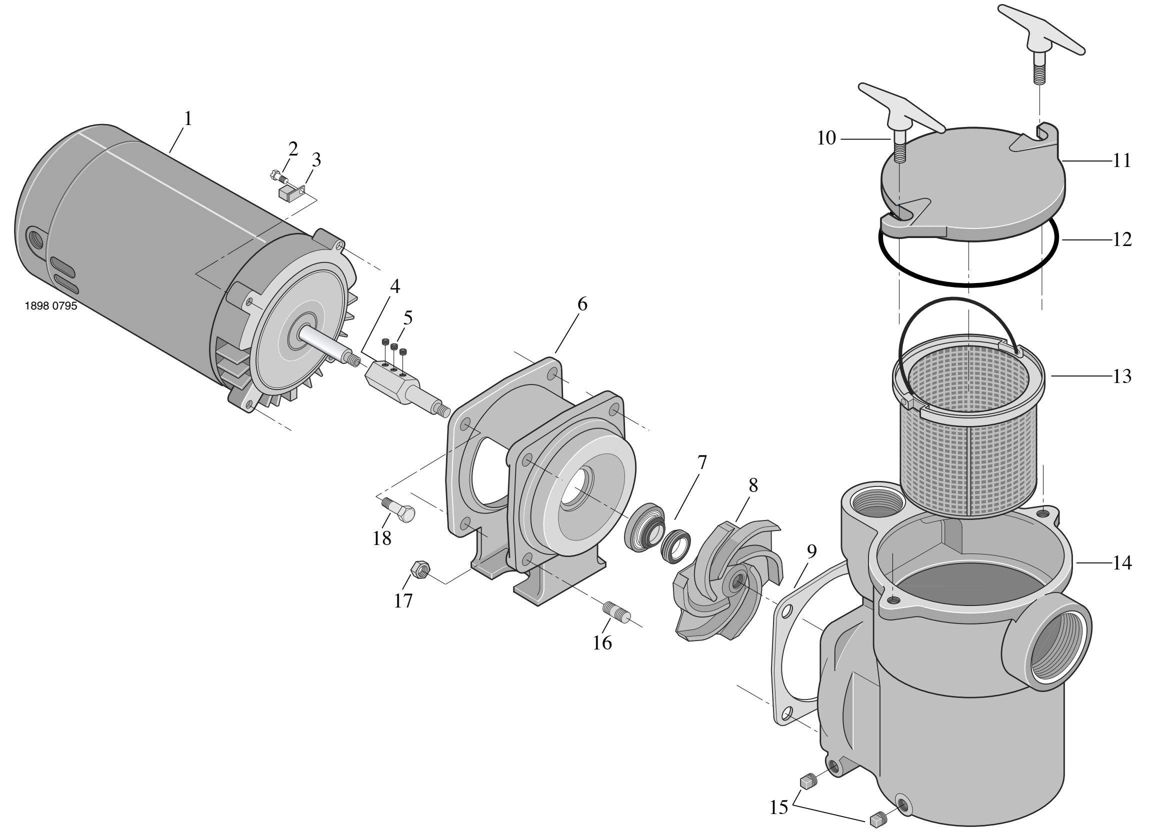


Figure 8

1. Match the numbers with the correct definition for each of the component parts for the above pump.

____________ Hair and Lint Basket
____________ Impeller
____________ Volute and Trap Body
____________ Trap Handles
____________ Motor
____________ Trap Cover
____________ Stub Shaft Assembly
____________ Adapter Bracket and Seal Plate
____________ Trap "O" Ring
____________ Drain Plugs
____________ Ground Lug
____________ Shaft Seal
____________ Gasket
____________ Set Screws

2. Answer the following questions "Yes" or "No".

A. This pump is considered a "Closed-Face Impeller Pump".

☐ Yes ☐ No

B. The impeller used on this pump is considered a "Non-Clogging Impeller".

☐ Yes ☐ No

C. Can an adjustment be made to the impeller setting?

☐ Yes ☐ No

D. When used as a self priming pump can you put a 90° elbow directly on the discharge of the pump?

☐ Yes ☐ No

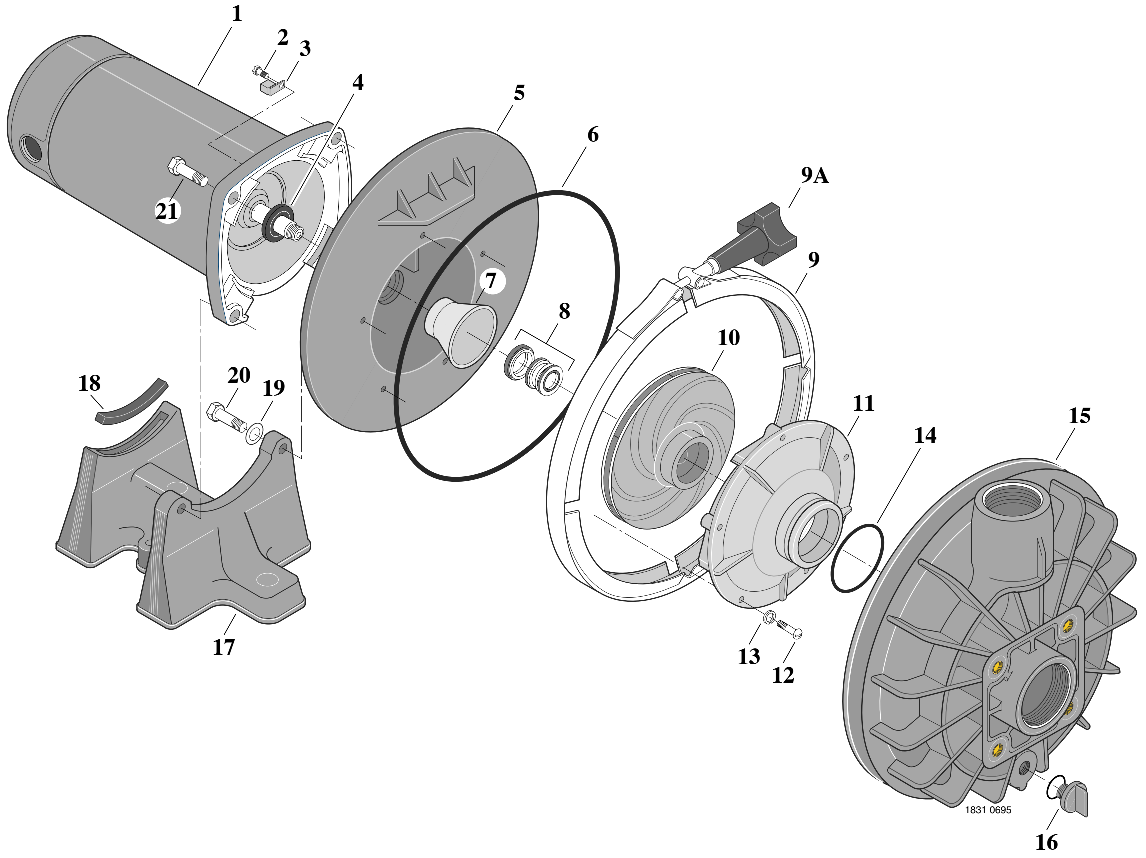


Figure 9

1. Match the numbers with the correct definition for each of the component parts.

__________ Clamp
__________ Seal Plate
__________ Diffuser "O" Ring
__________ Motor
__________ Volute or Tank Body
__________ Ground Lug
__________ Impeller
__________ Water Slinger
__________ Shaft Seal
__________ Base
__________ Drain Plug
__________ Heat Sink
__________ Motor Pad
__________ Diffuser
__________ Pump "O" Ring

2. Answer the following questions "Yes" or "No".

A. The impeller for this kind of pump can be adjusted.
☐ Yes ☐ No

B. This pump is designed with shaft seal heat protection.
☐ Yes ☐ No

C. The pump, as shown, is a self-priming pump.
☐ Yes ☐ No

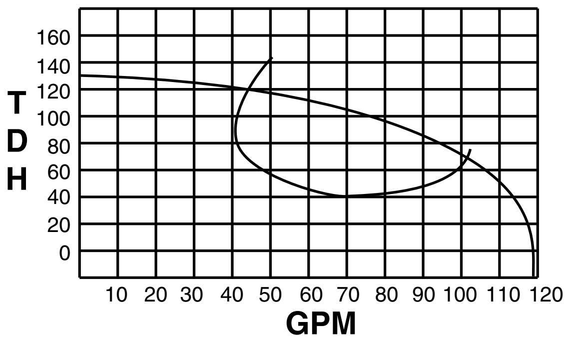


Figure 10A

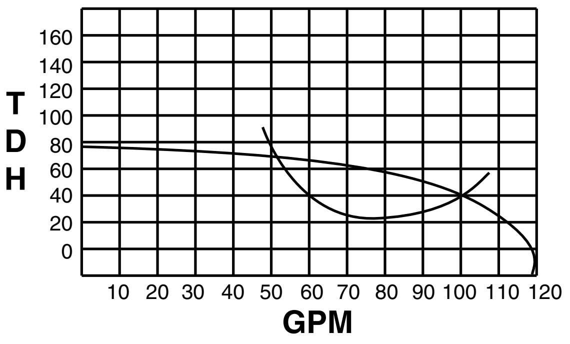


Figure 10B

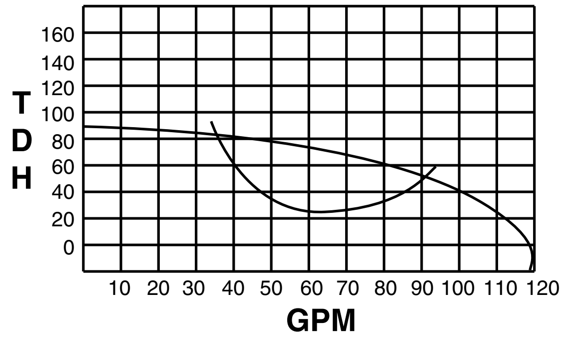


Figure 10C

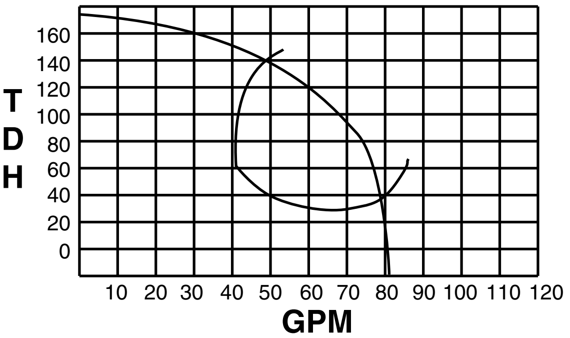


Figure 10D

Pump Curves - Sizing Pumps

The four pumps in Figure 10 are typical high and medium head pumps. Answer the following questions based on these pump curves:

1. Starting at 50 ft.. of head, which pump looses the most flow during the 10 lb. rise in filter pressure?

   A ☐ **B** ☐ **C** ☐ **D** ☐

2. Starting at 50 ft. of head, which pump looses the least flow during the 10 lb. rise in filter pressure?

   A ☐ **B** ☐ **C** ☐ **D** ☐

3. At 60 ft. of head, which pump delivers the most GPM?

   A ☐ **B** ☐ **C** ☐ **D** ☐

4. If the filter is clean and the pressure gauge is reading 15 lbs., and the vacuum gauge is reading 13 inches of mercury, how many GPM is pump C delivering?

   ____

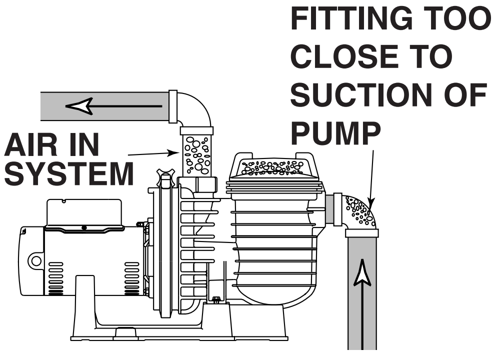
5. If you had 7 spa jets, each delivering 15 GPM, at a head loss of 40 ft. Which pump would you select?

   ____

6. On a filtration system, you need 75 GPM. Which pump would you choose?

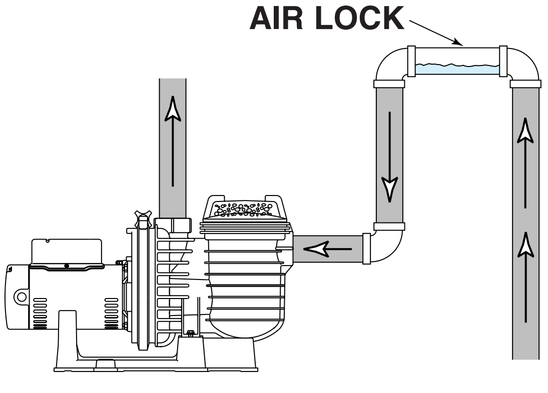
   ____

PLUMBING AND SAFETY TIPS



ALLOW 4 TIMES THE PIPE DIAMETER BETWEEN THE SUCTION PORT AND THE FIRST FITTING

Figure 11



KEEP SUCTION PIPES BELOW THE SUCTION PORT OF THE PUMP

Figure 12

Plumbing and Safety Tips:

1. Don't rely on the time clock being off when installing a new or replacement pump. Time clock may kick on and electrocute you.
2. When installing a pump more than 3 feet above water level and more than 10 feet from the water's edge, try to trench below the water level to a position directly below the suction of the pump. The vertical lift is still just 3 feet. Most self priming pumps should not have a difficult time priming at that lift.
3. Locating a pump in a low area can be dangerous. Make sure that it is in an area that has good drainage. Standing water can cause an electrical shock.
4. A loud pump does not always indicate a bearing problem. Restrict the discharge of the pump and listen to see if the pump quiets down. If it does, it's cavitation, not a bearing. Also, pushing down on the back of the motor, and/or lifting upon the back of the motor with a slight pressure may quiet the pump. If the noise diminishes, there is a possibility that the pump is hanging on the plumbing. Sometimes the pad may settle causing a level installation to be out of plumb. With one end of the pump rigidly attached to the plumbing and the other end a heavy motor, the motor shaft can can be binding on the front bearing and/or seal.
5. Some motors use the motor case to dissipate the heat from the inside of the motor. A pump that is improperly sized, or installed with the incorrect wire size, or not ventilated properly, and installed in direct sunlight can cause a burn if the hand is rested on the motor. Rule of Thumb: If you can leave your hand on the motor for a few seconds, it's probably O.K. If you can't leave your hand on it for any period of time, you may have one of the above problems. However, placing your hand on the motor to determine if it is too hot is not a judgement of whether or not the motor is operating properly. It is an indication that something may be wrong.

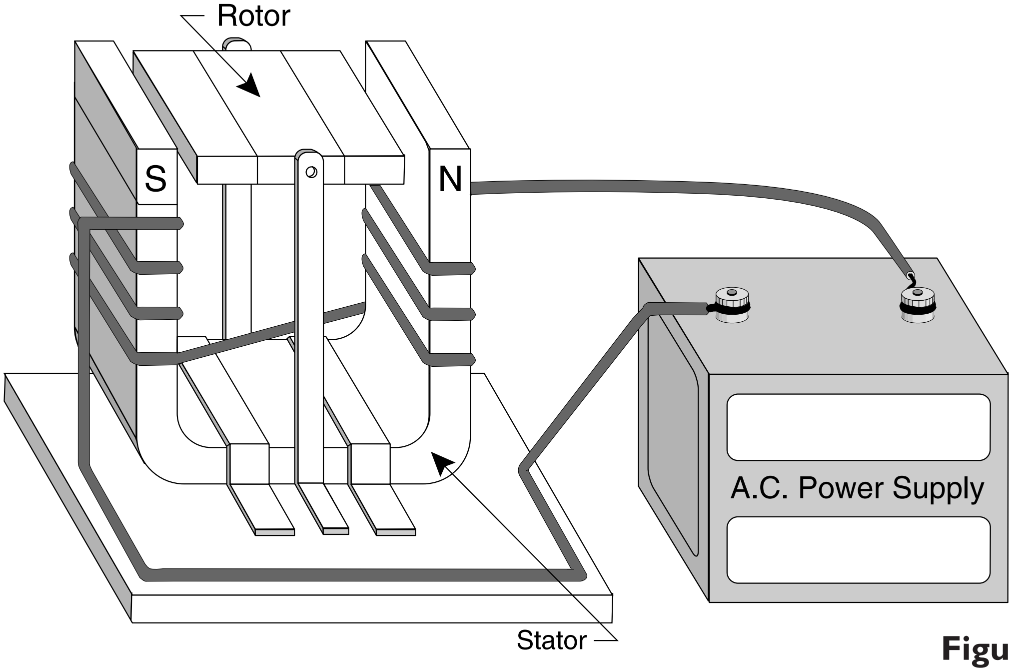


Figure 1

Swimming Pool and Spa Motors

Motors used with swimming pool, spa, and water feature pumps are designed to cover a wide range of applications, from fractional horsepower's to 50 HP or more. Some applications call for multiple speed or even variable speeds. The applications often require the motor to operate continuously in the direct sunlight at air temperatures of 120° F or higher, and in all types of weather.

The motor is one of the most important components of a centrifugal pump, yet, it is probably one of the most abused. Improper wiring, ventilation, and environmental factors are just a few enemies of good motor operations.

PRINCIPLES OF OPERATION

The electric motor is a device for converting electrical energy into mechanical energy. The motor, in general, has a set of insulated wire windings: starting and running. Located on the stator, they are connected to an external power source. The rotor consists of an iron bar and continuous wire loops. The magnetic field is established when currents flow in these conductors in a narrow air gap between the stator and the rotor. The current flow in the windings produces a rotating field that interacts with the rotor, causing the rotor to move, thus converting electrical energy into mechanical energy (Fig.l).

There are several different types of motor designs used for pool, spa, and water feature pumps, listed in ascending cost and efficiency:

1. ***Split Phase*** - Usually used in smaller circulation pumps which have very low starting torque requirements. Generally used in spa, jetted tub, above ground pools and small water feature pumps. Some are used on the lower end of in-ground pool and jet pumps. This design has a start winding and start switch, but no capacitors.
2. ***Capacitor Start*** - (Figure 2) - The most common type of single phase pump motor. A starting capacitor is in the start winding circuit to add faster, stronger starting torque with the high current surge. (150 - 175% of the full load).

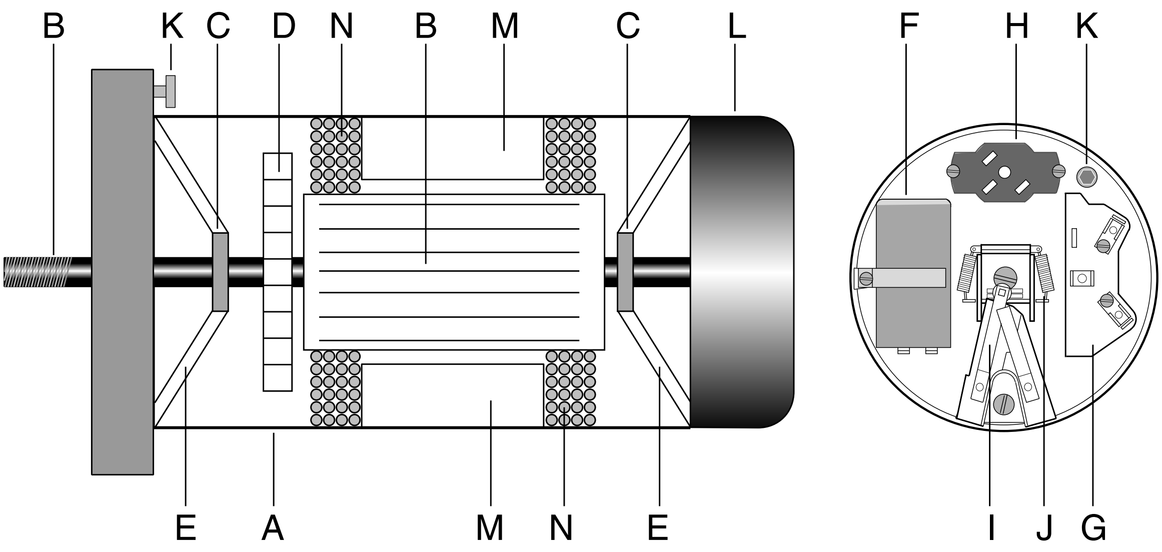


Figure 2

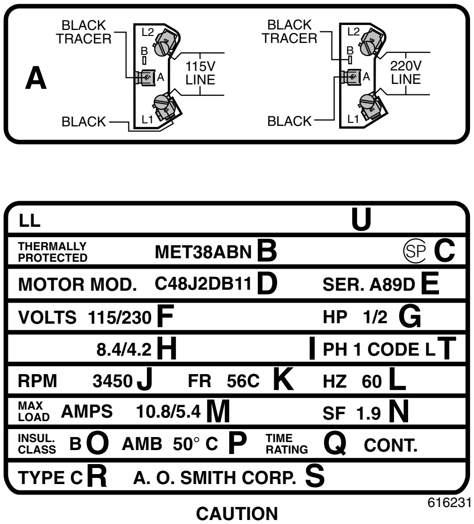
2. *Capacitor Start. (Cont.)* - This gives the motor a starting current lower than the split phase equivalent. The operation is similar to the split phase in that there is a start switch to take the start winding and capacitor out of the circuit once the motor reaches 2/3 to 3/4 of full speed (Figure 2).

BASIC COMPONENT PARTS (Figure 2)

(a) Main Frame (stator and coils)
(b) Rotor & Shaft Assembly
(c) Front and Rear Bearings
(d) Fan
(e) End Frames
(f) Capacitors (where used)
(g) Terminal Board
(h) Thermal Overload Protector
(i) Start Switch or Centrifugal Contactor
(j) Governor
(k) Ground Terminal
(l) End Cover
(m) Stator
(n) Stator Windings or C

3. *Capacitor Start/Capacitor Run (CSR)*
These are known as “energy-efficient” motors. They have a starting capacitor as in Figure 2 above but have an additional capacitor The running capacitor helps to smooth out the AC current flow and minimizes internal heat buildup, which is lost energy and higher energy costs. The running capacitor is combined with more metal in the rotor and stator, CSR motors more effectively convert electrical energy to mechanical energy resulting in less loss to heat. This is why CSR motors can operate in higher ambient temperatures with less thermal overloading problems and deliver a longer service life in the windings of the stator, bearings, etc.

4. *3 PHASE*
This is the simplest, most efficient design. It’s use is limited to commercial and industrial applications since three phase power is not available in residential areas. There are 6 motor lead wires and no operating capacitors. They operate much more efficiently at lower amps and watts. However, they require costly external relays or magnetic contactors to be installed in the wiring to the motor.



CAUTION

DO NOT OPERATE MOTOR WITHOUT CONNECTING GROUND WIRE TO GREEN GROUNDING SCREW. DO NOT CONNECT TO A POWER SOURCE OTHER THAN THAT SPECIFIED ON NAME PLATE. COVER MUST BE REPLACED. FAILURE TO FOLLOW THESE INSTRUCTIONS CAN RESULT IN SERIOUS OR FATAL INJURY.

616230-2

Figure 3

HIGH SERVICE FACTOR MOTOR

HP	SF	MAX. HP
1/3	1.95	.65
1/2	1.90	.95
3/4	1.65	1.25
1	1.65	1.65
1.5	1.47	2.20
2	1.30	2.60

LOW SERVICE FACTOR MOTOR

HP	SF	MAX. HP
1/2	1.30	.65
3/4	1.27	.95
1	1.25	1.25
1.5	1.10	1.65
2	1.10	2.20
2.5	1.04	2.60

Figure 4

Motor Nameplate

Everything that you need to know about swimming pool, spa, and water feature pumps is on the nameplate. (See Figure 3). It is important that the pump specifier, dealer and installer understand each marking on a conventional pump motor nameplate for safety, proper installation and servicing.

A – Most pump motors are dual voltage and therefore can be run on either 115 or 220 volts. If 230 volts where applied to the motor when it is connected for 115 volts, chances are high that the motor will burn out immediately. If 115 volts are applied to the motor when it is connected to 220 volts, chances are the motor may run or not run, but will not come up to speed.

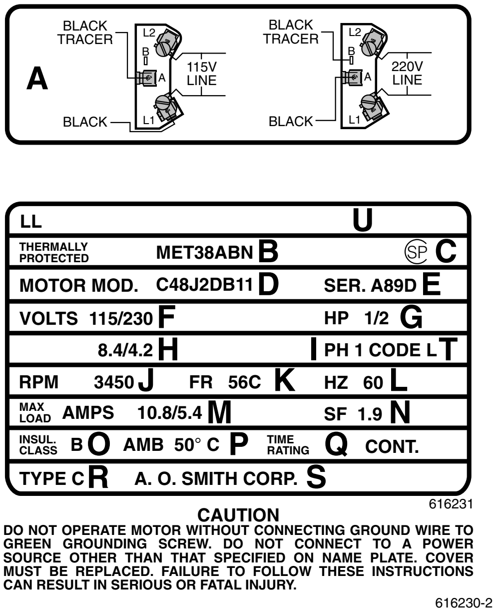
B – Thermal Overload Protector. This device is sensitive to heat and current flow. It acts as a breaker. This protector automatically shuts off the motor if the internal temperature becomes too hot.

The motor will restart automatically when the motor cools. The motor will continue to shut itself off until the problem is corrected or until the protector fails. Always replace the Thermal Protector with the same number stamped on the block. If there is a break in the current flow the motor will not start or restart until the problem is corrected.

C – The Canadian Standard Association (CSA) emblem indicates that the motor is constructed in accordance with the standards established by CSA and therefore is satisfactory for installation in Canada. UL is the emblem for Underwriters Laboratory. UR is the UL recognized component of a system, such as a component in a spa pac.

D – The motor model number identifies the motor type parts that need to be obtained and determines the exact electrical characteristics, if there is a question on electrical performance. It is vital to provide this number whenever seeking a replacement motor or parts for a motor

E – Serial number - This code tells the month, year, and day the motor was manufactured.



LL U
THERMALLY PROTECTED MET38ABN B SP C
MOTOR MOD. C48J2DB11 D SER. A89D E
VOLTS 115/230 F HP 1/2 G
8.4/4.2 H I PH 1 CODE L T
RPM 3450 J FR 56C K HZ 60 L
MAX LOAD AMPS 10.8/5.4 M SF 1.9 N
INSUL. CLASS B O AMB 50° C P TIME RATING Q CONT.
TYPE C R A. O. SMITH CORP. S
616231

CAUTION
DO NOT OPERATE MOTOR WITHOUT CONNECTING GROUND WIRE TO GREEN GROUNDING SCREW. DO NOT CONNECT TO A POWER SOURCE OTHER THAN THAT SPECIFIED ON NAME PLATE. COVER MUST BE REPLACED. FAILURE TO FOLLOW THESE INSTRUCTIONS CAN RESULT IN SERIOUS OR FATAL INJURY.
616230-2

Figure 3

HIGH SERVICE FACTOR MOTOR

HP	SF	MAX. HP
1/3	1.95	.65
1/2	1.90	.95
3/4	1.65	1.25
1	1.65	1.65
1.5	1.47	2.20
2	1.30	2.60

LOW SERVICE FACTOR MOTOR

HP	SF	MAX. HP
1/2	1.30	.65
3/4	1.27	.95
1	1.25	1.25
1.5	1.10	1.65
2	1.10	2.20
2.5	1.04	2.60

Figure 4

F – Voltage rating for the motor - Either 115 or 230 volts. Note the wiring terminal diagram for correct connections for either voltage.

G – Nominal or "Advertised" HP of the motor.

H – The amps listed are for nominal HP and should not be used for sizing the wire or setting the circuit breakers. (See M, Max Load Amps).

I – Almost all residential installations are single phase (normal house current). Commercial pumps are often 3-phase, with six wire leads coming out of the motor.

J – 3450 RPM is the standard speed for pump motors. 1750 RPM is used in larger commercial pumps and in 2 speed pumps for the slower speed and energy conservation.

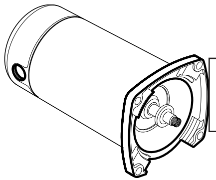
K – Motor frame size - This is important when a motor is being replaced. For example, a 48J frame is of a different dimension than a 56J. Frame size is determined by measuring the distance from the center of the motor shaft to the base of the motor mount, times 16. i.e. 3" x 16 = a 48 Frame.

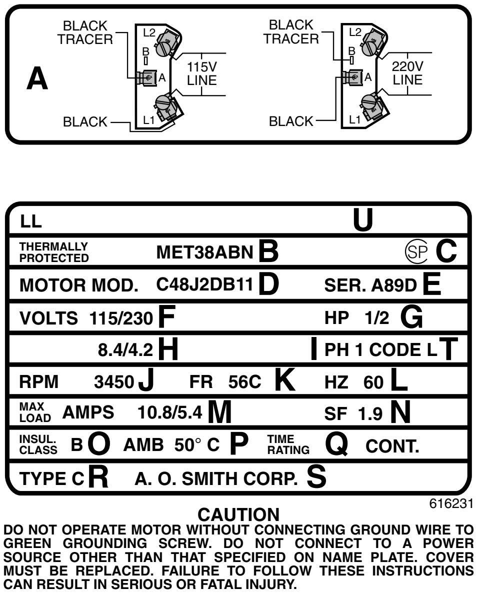
L – Hertz (HZ) is the term for cycle frequency of alternating current (AC). 60HZ (cycles) is the only frequency used in the United States. 50HZ is found in many other countries.

M – Maximum load amps designates the maximum amount of amperage drawn by a motor when it is operating at its full load horsepower rating. Maximum load amperage is **IMPORTANT**. It is the value to which all circuit breakers, fuses, heaters and wire must be sized. Never size any of these components to an amperage value that is less than the maximum load amperage drawn by the motor as designated on the data plate. Any amperage measurement drawn by the motor above its max. load amps would be considered an overload, which can have a variety of causes or effects.

N – The service factor of an alternating current electric motor, as defined by (NEMA) National Electrical Manufactures Association, is a multiplier which, when applied to the name plate HP rating, indicates the maximum safe operating HP at which the motor can be loaded for continuous duty operation.

High and Low Service Factor (Figure 4) - An electric motor may be rated as either a 1 or a 1-1/2 HP. However, when the motor is rated as a 1-1/2 HP, its service factor would change from 1.65 to 1.1. Both motors have the same full load HP capacity, and the maximum load amperage for both motors would be the same.





LL U
THERMALLY PROTECTED MET38ABN B (SP) C
MOTOR MOD. C48J2DB11 D SER. A89D E
VOLTS 115/230 F HP 1/2 G
8.4/4.2 H I PH 1 CODE L T
RPM 3450 J FR 56C K HZ 60 L
MAX LOAD AMPS 10.8/5.4 M SF 1.9 N
INSUL. CLASS B O AMB 50° C P TIME RATING Q CONT.
TYPE C R A. O. SMITH CORP. S
616231

CAUTION
DO NOT OPERATE MOTOR WITHOUT CONNECTING GROUND WIRE TO GREEN GROUNDING SCREW. DO NOT CONNECT TO A POWER SOURCE OTHER THAN THAT SPECIFIED ON NAME PLATE. COVER MUST BE REPLACED. FAILURE TO FOLLOW THESE INSTRUCTIONS CAN RESULT IN SERIOUS OR FATAL INJURY.
616230-2

Figure 3

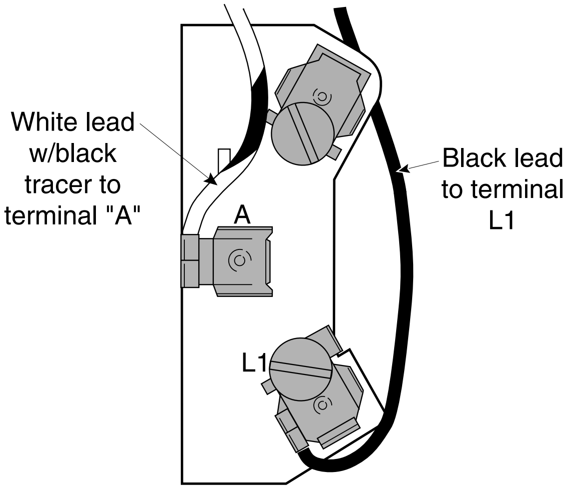


Figure 5

O – This is the insulation class as designated by NEMA. It designates the temperature it can withstand with out being damaged.

P – This is the maximum ambient temperature of the surroundings that the motor should be subjected to.
40° C = 104° F 50° C = 124° F

Q – This means the motor is suitable for operation on a continuous basis at its rated load without a break.

R – This is the electrical type, with most motors being capacitor start.

S – Identifies the manufacturer. Consult their instruction manual for proper installation and operation.

T – The code is a letter designation for locked rotor kVA per HP as measured at full voltage and rated frequency.

U – This symbol designates UL component recognition. UL standard 1081 covers swimming pool/spa pumps.

Exercise:

Answer the next 3 questions using the sample Data Plate in Figure 3.

1. What size circuit breaker would you use if this pump was connected to 115 volts?________
2. What is the Max Load HP of this pump?________
3. Using the Charts and Tables, pages 58 & 59, what size wire would you use for a 200 ft. distance?

   115 volt________ , 230 volt________ ,
   230 volt 3-phase________.
4. Is the pump in Figure 5 wired for 115 volt or 230 volts?________
5. Using the Charts and Tables, Page 57, complete the following chart.

Note: cost of electricity is 15 cents per kilowatt hour.

Motor HP	Cost Per Hour	8 Hour Day	Week	Month	Year
1/2					
3/4					
1					
1-1/2					
2					
3					

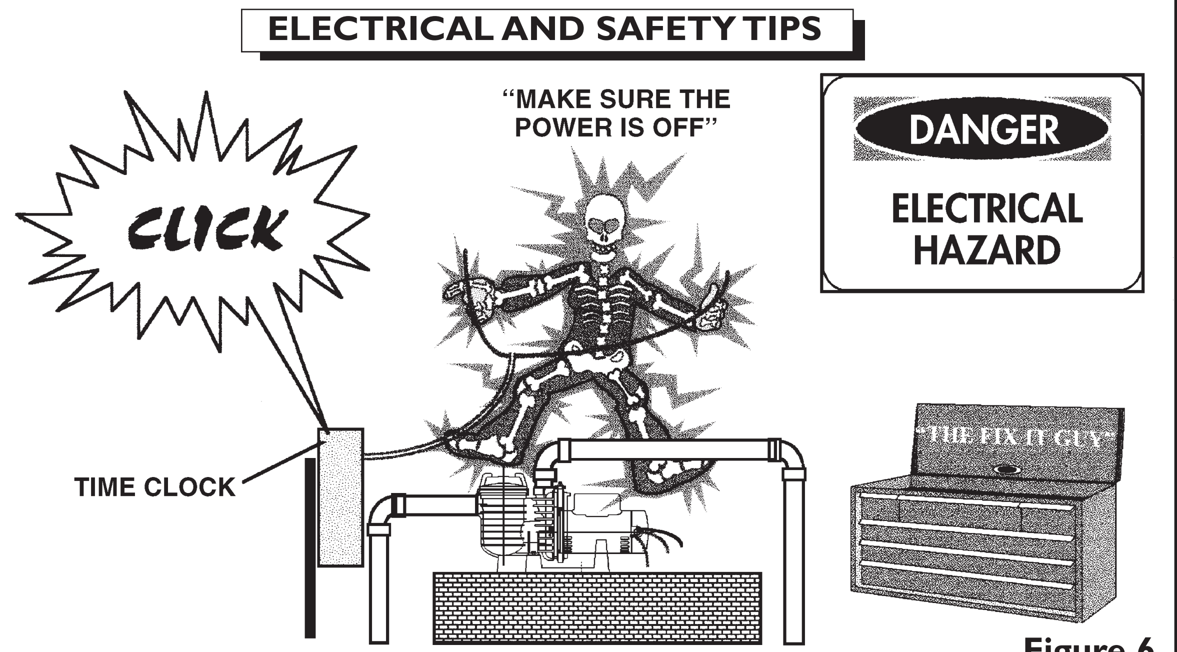
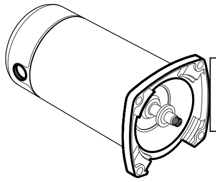


Figure 6

Electrical & Safety Tips:

1. Figure 6 - Never assume that the power is off. A time clock could "CLICK ON" and electrocute you. Always shut off the main power at the master breaker before working on motor.
2. Ventilation - Motors need air circulating to keep the temperature down. A rule of thumb is to provide at least 1 square foot of vent space at the top of an equipment room and the bottom of the equipment room for each horsepower of the motor for adequate ventilation. This is in addition to other types of equipment that require ventilation, such as a heater.
3. Use a ventilated motor cover to protect the motor from the elements, such as rain and the sun.
4. Don't use the pool while electrical devices are in the water. Pool drainers may have a frayed electrical cord. As an extra precaution, plug the electrical device into an outlet that has a GFCI protector.
5. Chemical Storage - Keeping chlorine, acid and other chemicals in close proximity to the pool equipment will shorten the life of almost everything metal in the area.
6. Improperly sized and/or wired pumps may have very hot motor casings. Over-loaded, under-wired, and poorly-ventilated motors can have very hot casings. Hot enough to burn your hand.
7. Refer to the motor wiring diagram before making any electrical connections. Always connect the ground wire first.



Approximate Cost of Operating Electric Motors

Motor HP	*Average Kilowatts Input or Cost per Hour Based on 1 Cent per Kilowatt Hr.		Motor HP	*Average Kilowatts Input or Cost per Hour Based on 1 Cent per Kilowatt Hr. 3-Phase
	1-Phase	3-Phase		
¼	.305	—	15	12.8
⅓	.408	—	20	16.9
½	.535	.520	25	20.8
¾	.760	.768	30	25.0
1	1.00	.960	40	33.2
1½	1.500	1.41	50	41.3
2	2.000	1.82	60	49.5
3	2.95	2.70	75	61.5
5	4.65	4.50	100	81.5
7½	6.90	6.75	125	102
10	9.30	9.00	150	122
			200	162

*For any other rate multiply by the rate:

Example: To determine cost of operating a 3/4 HP single phase motor at 3 cents per kilowatt hour multiply .760 X 3 = 2.280 cents or approximately 2¼ cents per hour.

ELECTRIC POWER

AC = Alternating current power
DC = Direct current
E = Volts = Electrical pressure (similar to head)
I = Amperes = Electrical current (similar to rate of flow)
W = Watts = Electrical power (similar to head capacity)
kW = Kilowatts = 1000 watts
Apparent Power = Volts x amperes = Voltamperes
Apparent Power - EI
Useful Power W = EI x P.F.
Power factor = ratio of useful power to apparent power

Power factor = PF = $\frac{W}{EI}$

kW Hr. = Kilowatt hour
Single phase power W = E x I x PF
3 Phase Power W = 1.73 x I x PF
Where E = Average voltage between phases
I = Average current in each phase

HORSEPOWER

1 HP equals. . .
.746 kilowatts or 746 watts
33,000 ft . lbs. per minute
550 ft. lbs. per second

WATER HORSEPOWER

$$= \frac{\text{GPM x 8.33 x Head}}{33{,}000} = \frac{\text{GPM x Head}}{3960}$$

GPM = Gallon per Minute
8.33 = Pounds of Water per Gallon
33,000 = Ft.-lb. per Minute in one HP

LABORATORY BHP

$$= \frac{\text{Head x GPM x Sp. Gr.}}{\text{3960 x Eff.}}$$

GPM = Gallon per Minute
Head = Laboratory Head (inc. column loss)
Eff. = Pump Only Efficiency

MOTOR INPUT HP

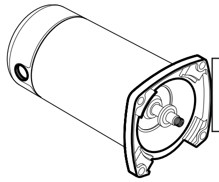
$$= \frac{\text{Laboratory BHP}}{\text{Motor Eff.}}$$

Total BHP from above
Motor Eff. from Manufacturer

UNIT EFFICIENCY

$$= \frac{\text{Water Horsepower}}{\text{Motor Input Horsepower}}$$

Water Horsepower from above
Input Horsepower from above



Single Phase Wire Size Selection Charts

115 Volts – 1 Phase

Amps	AWG Wire Size							
	14	12	10	8	6	4	2	0
2	595	946	1479					
3	397	630	986					
4	298	470	740	1161	1808			
5	238	378	592	926	1447			
6	198	315	493	774	1206	1842		
7	170	270	423	663	1033	1579		
8	149	236	370	581	904	1381		
9	132	210	329	516	804	1228	1871	
10	119	189	296	464	723	1105	1684	
12	99	158	247	387	603	921	1403	
14		135	211	332	517	789	1203	1622
16		118	185	290	452	691	1052	1420
18			164	258	402	614	935	1201
20			148	232	362	553	842	1136
22			134	211				
24			123	194				

Maximum Distance of Wire Run.

200 Volts – 1 Phase

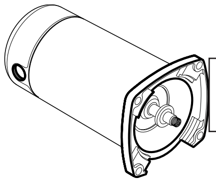
Amps	AWG Wire Size							
	14	12	10	8	6	4	2	0
2	1035	1644						
3	690	1096	1715					
4	518	822	1287					
5	414	658	1029	1615				
6	345	548	858	1346	2097			
7	296	470	735	1154	1797			
8	259	411	643	1010	1573	2403		
9	230	365	572	897	1398	2136		
10	207	329	515	808	1258	1922	2928	
12	173	274	429	673	1048	1602	2440	
14		235	368	577	899	1373	2091	2821
16		206	322	505	786	1201	1830	2469
18			286	449	699	1068	1627	2194
20			257	404	629	961	1464	1975
22			234	367	572	874	1331	1795
24			214	337	524	801	1220	1646
26				311	484	739	1126	1519
28				288	449	686	1046	1411
30				269	419	641	976	1317
35				231	359	549	837	1129
40					315	481	732	988
45					280	427	651	878
50					252	384	586	790
55						349	532	718
60						320	488	658

Maximum Distance of Wire Run.

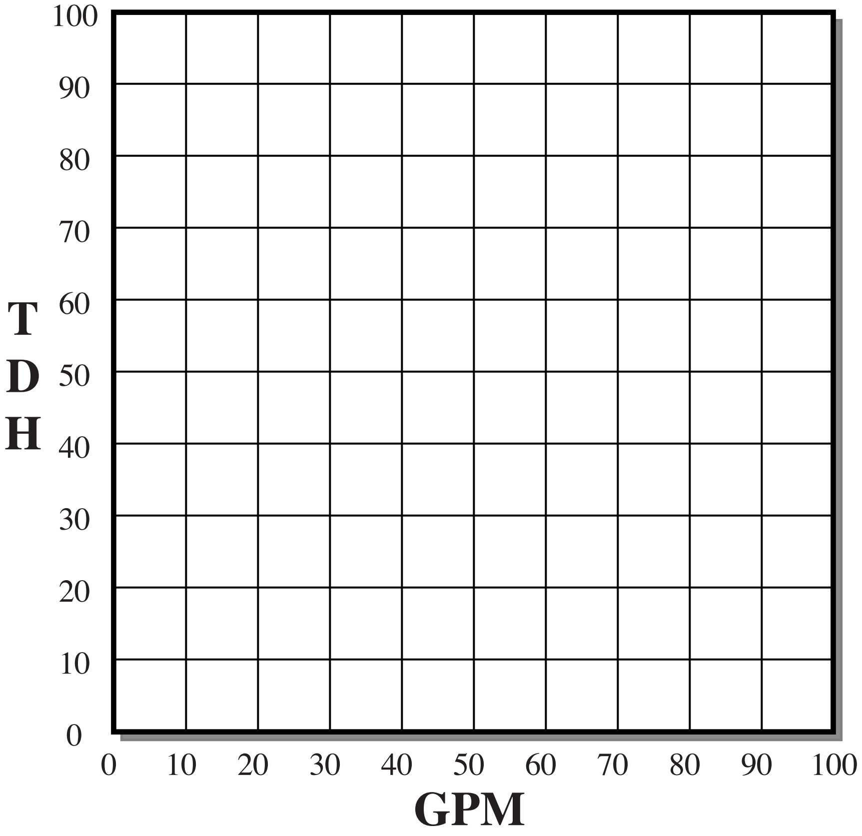
230 Volts – 1 Phase

Amps	AWG Wire Size							
	14	12	10	8	6	4	2	0
2	1190	1891						
3	794	1261						
4	595	946	1479					
5	476	756	1184	1858				
6	397	630	986	1548	2411			
7	340	540	845	1327	2067			
8	293	473	740	1161	1808	2763		
9	265	420	658	1032	1607	2456		
10	238	376	592	929	1447	2210	3367	
12	198	315	493	774	1206	1842	2806	
14		270	423	663	1033	1579	2405	3245
16		236	370	581	904	1381	2105	2839
18			329	516	804	1228	1871	2524
20			296	464	723	1105	1684	2271
22			269	422	658	1005	1531	2065
24			247	387	603	921	1403	1893
26				357	556	850	1295	1747
28				332	517	789	1203	1622
30				310	482	737	1122	1514
35				265	413	632	962	1298
40					362	553	842	1136
45					321	491	748	1009
50					239	442	673	909

Maximum Distance of Wire Run.



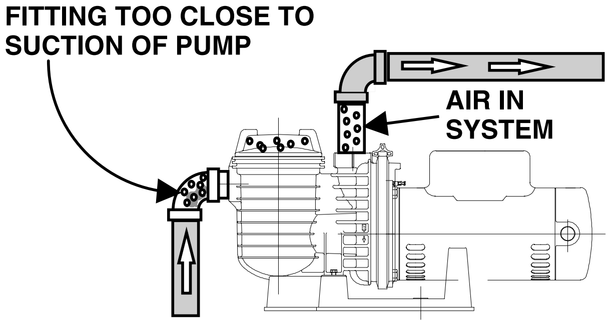
Pump Curve Graph



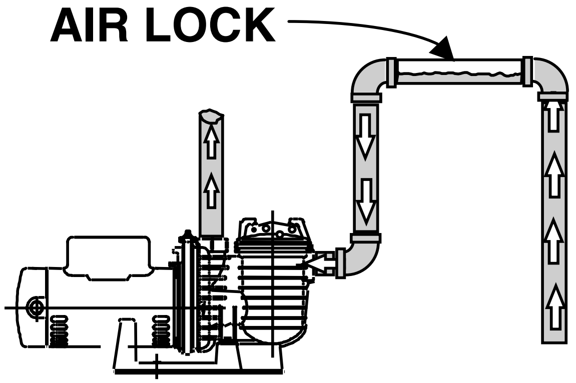
PLUMBING		SYSTEM READINGS					
Pipe Suction	Pipe Discharge	Vacuum x 1.13	Pump Pressure x 2.31	Filter Pressure x 2.31	Energy Used AMPS	Flow Meter GPM	System Head Loss
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH
FPS	FPS	HL	HL	HL			TDH

FPS = Feet Per Second
HL = Head Loss
TDH = Total Dynamic Head

Plumbing Tips

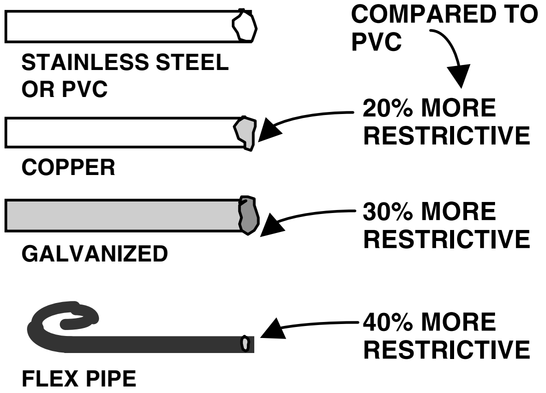


ALLOW 4 TIMES THE PIPE DIAMETER BETWEEN THE SUCTION PORT AND THE FIRST FITTING

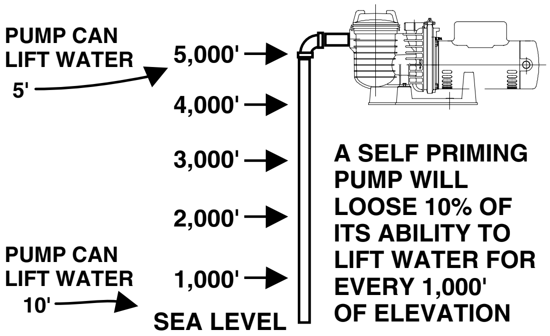


KEEP SUCTION PIPES BELOW THE SUCTION PORT OF THE PUMP

TYPE OF PIPE



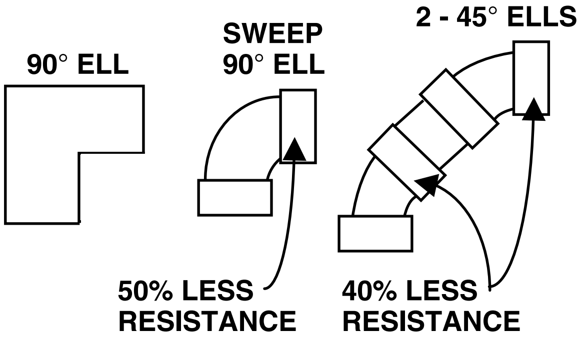
ATMOSPHERIC PRESSURE



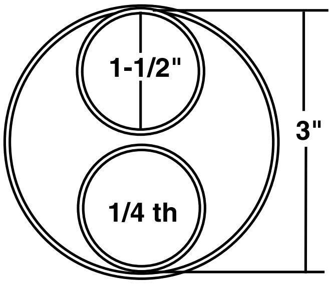
A SELF PRIMING PUMP WILL LOOSE 10% OF ITS ABILITY TO LIFT WATER FOR EVERY 1,000' OF ELEVATION

ATMOSPHERIC PRESSURE AT SEA LEVEL = 14.7 lbs.
ATMOSPHERIC PRESSURE AT 5,000 FEET = 12.0 lbs.

REDUCE RESISTANCE



MULTIPLE PIPES



A 1-1/2" PIPE CAN ONLY HANDLE 1/4 THE FLOW OF A 3" PIPE

USE THE PIPE SIZING CHARTS TO SIZE MULTIPLE PIPES TO REPLACE A SINGLE PIPE

1-1/2" = 44 GPM   3" = 160 GPM

- Long plumbing runs – Increase pipe size, don't increase pump horsepower.
- Restrict flow at the top of a waterfall, not at the pump.
- Balance the flow by looping the plumbing or tying in at the center and branching an equal distance in each direction.

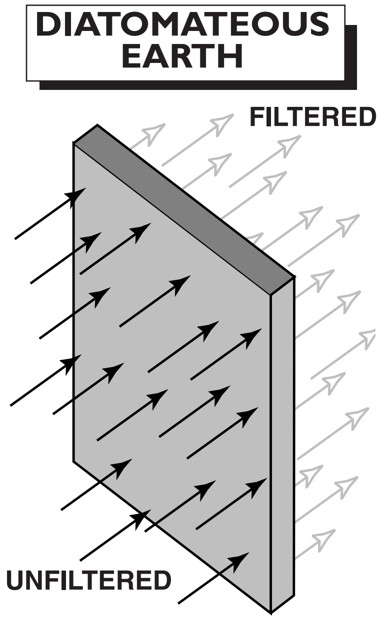


Figure 1

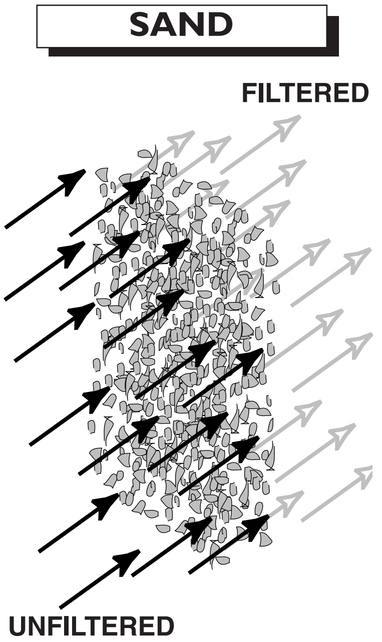


Figure 2

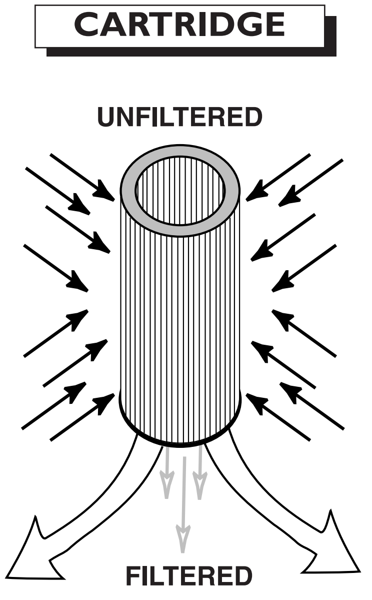


Figure 3

Swimming Pool, Spa, & Water Feature Filtration:

Filters used for swimming pools, spas and water features are designed to physically remove suspended particles from the water. The water containing the solid dirt particles passes through a filter medium. The medium retains the particles while the "filtered water" passes through.

Filter Media:

Generally, three types of filter media are used for removing the suspended dirt particles from water in a swimming pool, spa, or water feature.

1. Diatomaceous Earth (D.E.)
2. Silica Sand
3. Cartridge or Fiber

"Which Filter is Best"

This is an often asked question. All three of the filters are used in almost every kind of application. Filter selection is usually made because of the preferences of the specifier, or designer. "They specify what they like and have experience with". The best advice is to leave your options open and look at other types of filtration. Another type of filter may do the job better than what you normally use.

Exercise:

Complete the left side of the chart below.

	Micron Removal	Dirt Loading	Cost New	Cycle Time	Maintenance Time	Maintenance Cost	Replacement Cost (Internals)		Applications				
									Pool	Spa	Water Feature	Ponds	Fish Ponds
D.E.									2	4	4	4	4
SAND									3	3	2	1	1
CARTRIDGE									4	1	3	3	3
MEGA. CART.									1	2	1	2	2

1. Best 2. Very Good 3. Good 4. O.K.

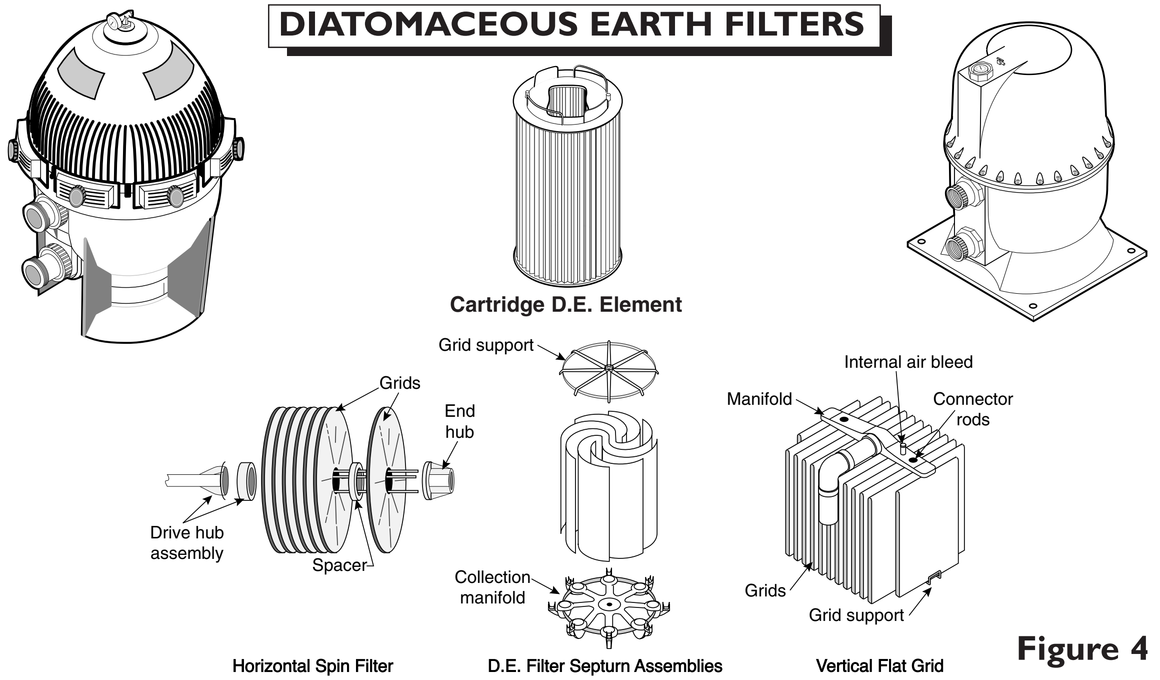


Figure 4

Diatomaceous Earth Filters:

Diatomaceous earth filters use, as a medium, the tiny skeleton remains of an animal called a “diatom”. Each tiny fossil is porous and contains many minute passages and channels. These channels and passages are so small that a layer of diatomite measuring 1/8 inch in thickness will provide a filters bed equivalent to 2 ft. of sand. Diatomite has the capability of retaining particulate matter so minute that even some bacteria can be filtered from the water.

Basic Design of a D.E. Filter:

D.E. filters generally are of the pressure type and are designed to operate at pressures up to 50 psi. There are some D.E. systems that are designed as vacuum type filters. These are usually found on large commercial swimming pools. The filter is located on the suction side of the pump (vacuum side). The water is pulled through the filter rather than pushed through, as in the case of the pressure type. The vacuum filter will be discussed in more detail in the Commercial Section (7) of this Manual. Tank construction is of various materials or a combination of materials. Stainless steel, plastic, and fiberglass are the main materials. These tanks are constructed in many different configurations, depending on the concepts of the designer.

Most tanks are two parts, a top, or lid, and a bottom, or in the case of a horizontal filter, a front and a back. Tank halves are held together with clamps, bolts, other type locking devices, again depending on the designer’s concept. A seal between the two halves is achieved with an “O” ring or gasket. The tank is supported by a base or legs. The tank support is designed to keep the filter elevated to provide clearance between the tank and the “pad” so that there is access to a tank drain. The tank support also has mounting holes so that the filter can be secured to the “pad”.

An inlet and an outlet fitting, usually 1-1/2” or larger, depending on the size of the filter, are located on the bottom half of vertical tank filters, and on the back half of horizontal filters. Having the inlet and outlet fittings on one half of the filter tank allows the other half to be removed for servicing and repair. At the top of the filter is a manual air relief, which usually is in conjunction with a pressure gauge. (See Figures 6 & 7).

The internal “grid assembly” of the filter is of various sizes and shapes, depending on the designer’s concept. The grids are usually made of a moderate temperature, high impact resistant plastic. The grids are covered by a “grid cloth” that is the support base for the D.E. cake. The individual grids are held together by the collection manifold and in some cases a support bracket. A collection manifold is located at the other end of the grids. The grids are held together by connecting rods between the support bracket and the manifold.

D.E. GRID

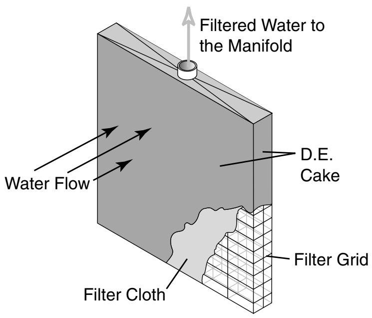


Figure 5

FILTER CYCLE

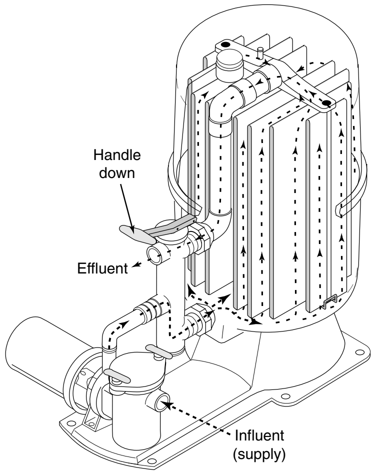


Figure 6

BACKWASH CYCLE

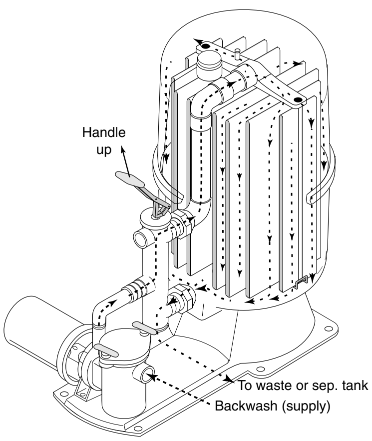


Figure 7

Basic Operation of a D.E. Filter:

Diatomaceous earth is fed into the suction side of the pump, either through the skimmer or a slurry pot, which is sent to the filter where it forms a cake on each of the filter grids or element. The water, under pressure, containing the suspended dirt particles, passes through the D.E. cake and the grid cloth, or element. The dirt particles become trapped in the tiny cracks and crevices of the diatoms. The filtered water passes through the grids/element and plumbing back to the swimming pool, spa, or water feature. (Figures 5 and 6).

Filter Cycle:

Water from the pump enters the filter through a series of valves or a "backwash valve". As it enters the filter, it encounters a baffle designed to deflect the water away from the grids and toward the bottom of the tank. This action sweeps the D.E. from the bottom of the tank and deposits it on the grids. The water, containing the suspended dirt particles, passes through the D.E. "cake", where the particles are removed. The filtered water then enters the supporting grid/element and proceeds to the outlet port of the filter where it returns to the original body of water. (Figure 6).

Backwash Cycle:

As the D.E. filter collects the dirt particles in the D.E. cake, the passageways for the water to flow become restricted. This resistance to flow causes the pressure to rise. When the pressure rises 10 psi higher than the original starting pressure, it is time to clean the filter. Cleaning the filter can be done manually by removing the grid assembly or element and hosing it off. The easiest way to clean the filter is to "backwash" it. By the use of gate valves or a "backwash valve", the flow in the filter is reversed. (Figure 7) This action breaks off the cake of D.E. containing the dirt particles. The dirty water is directed out of the filter to waste.

D. E. Substitutes:

There are several D.E. substitutes on the market. They offer some advantages and disadvantages as compared to D.E. The biggest advantage is that it does not require as much material as D.E., thus less cost. However, there are a number of disadvantages. Some do not backwash as well as the D.E. This results in a shorter 2nd cycle, 3rd cycle, etc. Others take longer than D.E. to fall off of the filter grid when the pump shuts off, making the maintenance of the filter a longer project.

These substitutes are continually improving. In time, they will probably perform as well as D.E., or even better.

PRE-COATING

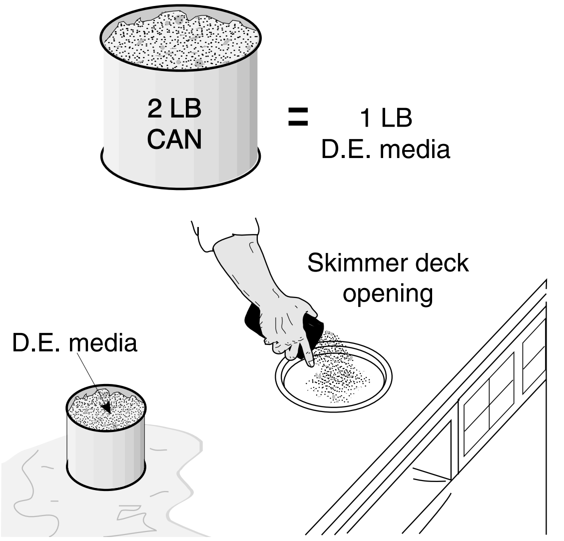


Figure 8

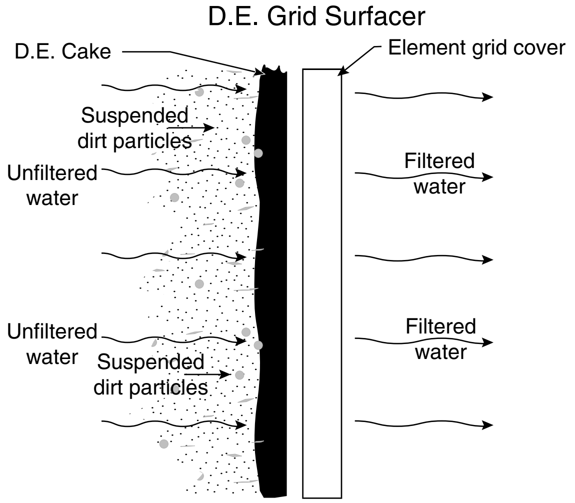


Figure 9

Pre-Coating the D.E. Filter Grids or Elements

On initial start-up or after the filter is cleaned, it is necessary to "pre-coat" the grids or elements with diatomaceous earth or a D.E. substitute. The rule of thumb for the amount of D.E. required is 1 lb. of D.E. per 10 sq. ft. of filter area. (A 2 lb. coffee can will hold approximately 1 lb. of D.E. (Figure 8).

Exercise:

A 50 sq. ft. filter requires how much D.E. to pre-coat the grids or element?

1 lb. of D.E. per 10 sq. ft. equals? ________ lbs.
How many 2 lb. coffee cans will it take? ________

The amount of a D.E. substitute that is required ranges from 1/2 lb. to 3/4 lb. per sq. ft. of ________

Exercise:

A 50 sq. ft. filter requires how much D.E. substitute to pre-coat the grids or element ________ lbs.

Velocity and its effects on D.E. filtration:

When designing a filtration system using D.E. filters, it is important to keep the velocity of the water as slow as possible. If the speed of the water is too great, the D.E. will be impacted into the grid cloth or element cloth and will not be released during the backwash cycle. The filter will have to be cleaned manually. In some cases, the filter grids or elements will need to be cleaned with special cleaners to remove the dirt particles that have imbedded themselves into the filter cloth. The filters are designed to hold the D.E. cake at low pressure. At "0" pressure, when the pump is shut off, the D.E. will fall off of the grids to the bottom of the tank. When the pump is restarted, the D.E. will re-coat to the grids or the elements. Slower water velocities will also provide longer filter cycles since the water passes filter the area through more of the grid or element, rather than being driven through at points closest to the outlet of the grid or element.

High velocities and high heat applications, such as spas, hot tubs, and therapy tanks, will wear down the plastic internals of the filter, causing sagging and warping, and eventually breaking down the grids. The filter media will pass through the grids and back to the original body of water. This can happen in just a few months, depending on how high the velocity and temperatures are.

FILTER SIZING

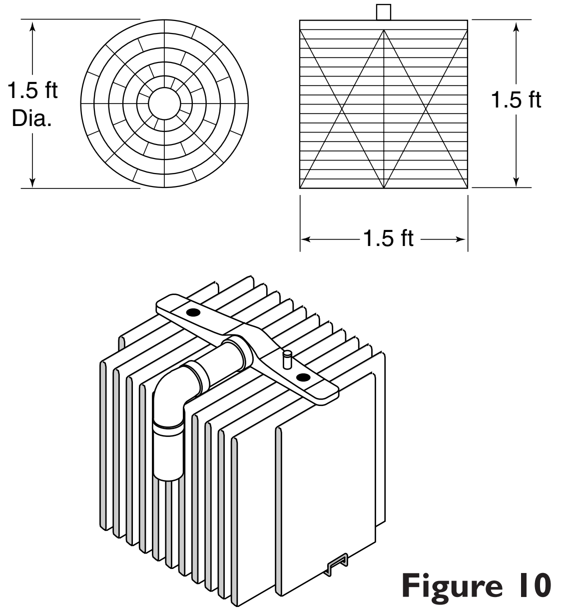


Figure 10

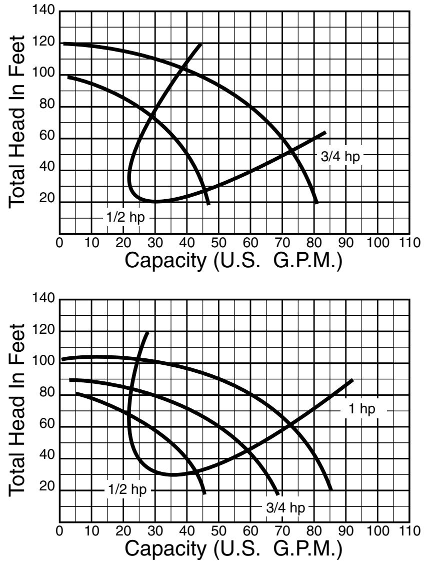


Figure 11

NOTE: D.E. sizing charts are located on Pages 5 through 10 in the Charts and Tables.

Sizing a D.E. Filter:

The size or sq. ft. area of a D.E. filter is determined by the surface area of the filter grid, minus the plastic grid structure of the grid itself. The sq. ft. of a D.E. element is determined by the actual sq. ft. of the cloth elements. (Figure 10)

Spin Grid = area of a circle, minus the 2” hub, times both sides, minus the percent the grid network takes up. (1 to 5% depending on the type.)

Formula: (Figure 10)

(.75 x .75) x 3.14 = 1.77 minus .262 (hub) = 150 x 2 (both sides) = 3 sq. ft. minus the plastic grid percentage, 5% = 2.85 sq. ft.

Square or Curved Grid = area of the grid, times both sides, minus the plastic grid percentage = sq. ft.

1.5 x 1.5 x 2 (both sides) = 4.5, minus the plastic grid percentage, 5% (. 11) = 4.39 sq. ft.

Selecting the Correct D.E. Filter:

It is important that the filter be sized to the pump rather than the gallons per minute calculated to turn the body of water over in the desired number of hours.

Example: (Figure 11, top)

20,000 gallon pool that requires an 8 hour turnover.

20,000 / 480 (minutes) = 42 GPM

With just the above information available, many filters are undersized. The problem is that the pump selected to do the job may be delivering a lot more flow than is required. The pump curve for a 3/4 HP pump, shown in Figure 11, top, is pump selected for the above pool. The resistance in the system is 60 ft. of head. The 3/4 HP pump will deliver 70 GPM, or 27 GPM more than is needed. The filter selected based on 43 GPM would probably be too small, causing short cycles and possibly excessive pressure in the system.

Filter Sizing Procedures:

The desired flow for most pressure D.E. filters is between 1.5 and 2 GPM per sq. ft. of filter area. It should be sized so that the flow is not below the 1.5 GPM nor above the 2 GPM range. In certain filter designs, flows below 1.5 GPM, there is not enough flow to adequately backwash the filter. Other designs have poor filter cycles if the flow is over 2 GPM. 1.5 GPM is the ideal flow rate. It allows for longer filter cycles and enough flow for backwashing.

Exercise:

Using the pump curves in Figure 11, bottom, what size D.E. filter would you select for a 18,000 gallon pool requiring a 6 hr turnover. The resistance of the system is 50 ft. of head.

6 hr. turnover ______GPM, Pump Selected ______HP, Pump Delivers ______GPM,

Filter Selected ______sq. ft.

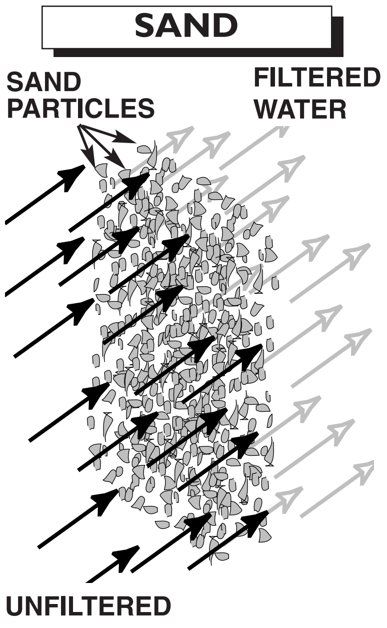


Figure 12

FILTER DESIGN

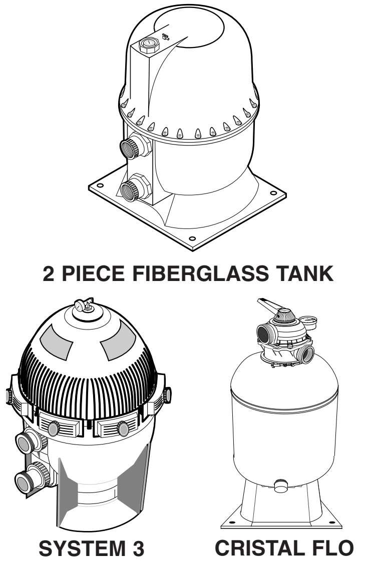


Figure 13

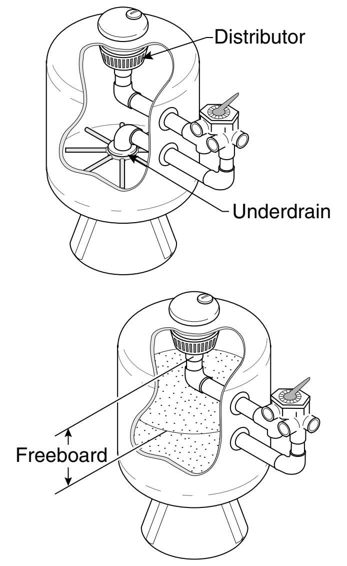


Figure 14

Sand Filter:

Sand filtration is the oldest form of filtration known to man. It is believed that the caveman dug holes near a river bank allowing the water to seep through the sandy soil and fill up the holes with "filtered" water. The Roman Baths were filtered by water flowing by gravity through a sand bed in an urn, or other vessel, exiting the bottom and returning to the Baths, by gravity, through water falls, fountains, and statuary.

Basic Operation of a Sand Filter: (Figure 12)

Water, containing the suspended dirt particles passes through the sand grains, either by gravity or pressure. The dirt particles are trapped in the tiny openings, cracks, and crevices. Over time, the sand grains become round smooth, becoming less effective as a filter media. This process may take as little as a year or it can take many years, depending on the velocity of the water.

Basic Design of a Sand Filter: (Figs. 13 & 14)

Like the D.E. filters, sand filters are generally of the pressure type and are designed to operate at pressures up to 50 lbs. Tank construction is of various materials or combination of materials. Stainless steel, plastic, and fiberglass are the most common materials used. These tanks are constructed in many different configurations, depending on the concepts of the designer. One piece tanks with a lid to access the internal parts and two piece tanks that are held together with clamps or bolts are the most common.

The filter is supported by legs or a base. There is an air bleed located at the top of the filter along with a pressure gauge. A drain is located at or near the bottom of the filter tank to allow for draining and servicing of the filter.

The internal components of the sand filter are very simple. At the top of the filter is a "distributor". Its purpose is to spread the unfiltered water evenly over the surface of the sand bed. The sand bed is generally one to two feet below the distributor. The upper area is called the "freeboard". This area is necessary for the proper distribution of the incoming water. At the bottom of the tank is the "underdrain assembly" designed to collect the filtered water after it has passed through the sand bed. The underdrain assembly has a series of "laterals" that have very small slots that are large enough for the water to flow through, but small enough that the sand grains can not pass.

Sand filters have a valve attached to the filter tank to direct the flow of water through the tank. The main purpose of the valve is to reverse the flow of water in the tank to "Backwash" the dirt out. Filter tanks that separate at the middle usually have the valve attached to the inlet and outlet on the lower half of the tank. One piece tanks may have the valve attached to either the inlet and outlet on the side of the tank or on the top. Filters that have the valve on the top of the tank require the valve assembly to be removed to service the tank. Many of these valves have multiple purposes and are called Multiport Valves. These valves will be discussed at the end of this section.

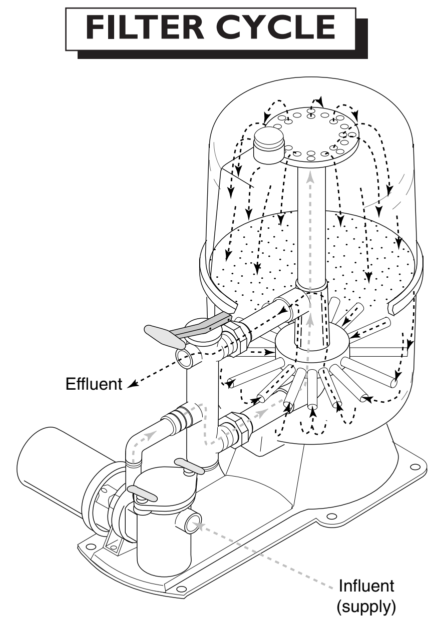


Figure 15

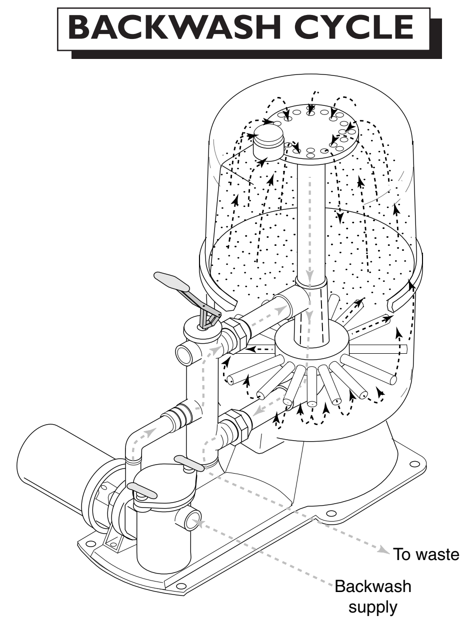


Figure 16

Filter Cycle:

Water from the pump enters the filter through a series of gate valves or a "backwash valve". The backwash valve can be on top of the tank or installed at the inlet and outlet on the side of the tank, depending on the designer's concept of how the filter should perform. The water, containing the dirt particles, is directed to the distributor where it is evenly spread over the sand bed. The water is driven into and through the sand bed, trapping the dirt particles. The filtered water enters the underdrain lateral assembly and is directed out of the tank and back to the original body of water. (Figure 15)

Backwash Cycle:

As the dirt particles are trapped in the sand bed, the passageways become restricted. It becomes difficult for the pump to push the water through the sand, causing the pressure to rise. When the pressure rises a predetermined amount, usually 5 to 10 pounds over the original starting pressure, it is time to clean the filter. By opening and closing a series of gate valves, or changing the position of a backwash valve, the flow in the filter is reversed. The water now enters the tank through the tank outlet to the bottom of the lateral assembly. It proceeds through the sand bed causing the sand bed to expand, freeing the trapped dirt particles. The dirt particles, being lighter than the sand grains, proceed to the top of the tank, through the distributor through the tank inlet and exit to waste. There is usually a clear "sight glass" installed in the waste line to observe the water being ejected to waste. When the water appears to be clean the backwash cycle is complete. This backwash cycle can take as little as a couple of minutes to as much as 7 or 8 minutes, depending on how deep the dirt particles were embedded and the type of dirt particles the filter was removing. Heavy clays and oils will take longer to remove than dust or insects.

When the filter is clean, the sand bed has been rejuvenated and the filter can be placed back in the filter mode. (Figure 16).

Filter Square Footage:

Sand filters are rated in square feet. The surface area of the sand bed is the square footage of the filter.

Examples:

I. A round tank - 24" in diameter
Formula - Area = πR^2
Area = 3.14 x (1' x 1') = 3.1 sq. ft.

II. A square tank - 3' long by 2' wide
Formula - Area = length x width
Area = 3' x 2' = 6 sq. ft.

SAND FILTER SIZING

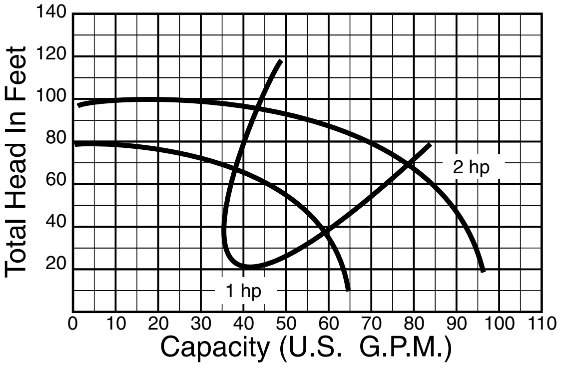


Figure 17

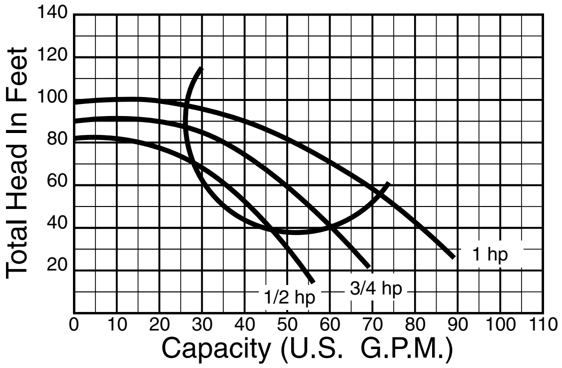


Figure 18

NOTE: Sand sizing charts are located on Pages 11 through 15 in the Charts and Tables.

Selecting the Correct Size Filter for a Swimming Pool, Spa, or Water Feature:

Like all filters, it is important that the filter be sized to the GPM the pump is delivering, rather than the gallons per minute that has been calculated for the correct turnover rate.

Example: (Figure 17)

2,000 gallon commercial spa with a 30 minute turnover at 40 ft. of head loss.
2,000 / 30 min. = 67 GPM

The 2 H.P. pump in Figure 17 is delivering almost 90 GPM. If we sized the filter for 67 GPM and pump is delivering 90 GPM, the filter would be undersized causing short cycling, possibly channeling, and do a poor job of filtering the spa.

Filter Sizing Procedures:

The desired flow for most pressure high-rate sand filters is between 15 and 20 GPM per sq. ft. of filter area. Flow rates below 15 GPM may not be sufficient in many cases to back wash the filter properly. Flows over 20 GPM will drive the dirt particles deep into the sand bed, which may not be discharged during backwash. In many filters, flows of 20 GPM or more may "channel" the filter.

Channeling is when the sand bed is "short circuited" allowing unfiltered water to be returned to the main body of water.

To size a sand filter, the procedure is as follows:

Divide the recommended flow rate for the filter into the GPM produced by the pump

---

Example: (Figure 18)

A pump is delivering 73 GPM. We want to size the filter at the recommended flow rate of 15 GPM per sq. ft. of filter area.
73 / 15 = 4.9 sq. ft. filter.

What size sand filter would you use for a 22,500 gallon pool that requires an 8 hour turnover? Use the pump curve in figure 18 at 60 foot of head loss. The best flow rate for the sand filter is 15 GPM, per sq. ft.

Turnover Rate ________GPM

Pump Size ________HP

Pump Delivers ________GPM

Filter Size ________sq.ft.

VELOCITY AND THE SAND FILTER

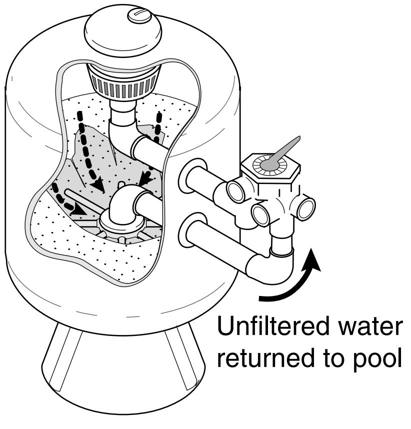


Figure 19

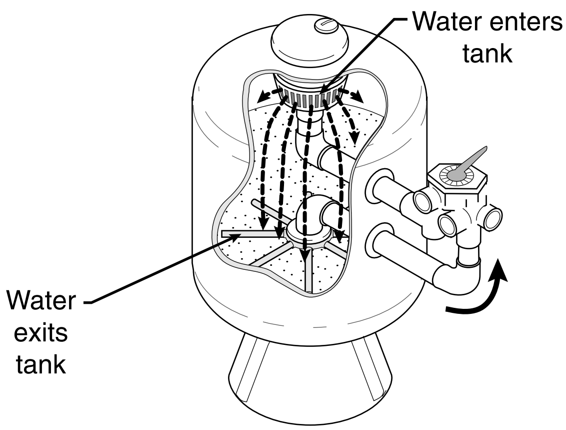


Figure 20

Velocity and its Effect on Sand Filtration:

When water enters a sand filter, it heads directly to the easiest way out of the tank. In a typical sand filter, the easiest way out is the underdrain laterals. The faster the water is moving (high velocity), the faster it passes through the sand bed on its way to the laterals. High velocity will drive the dirt particles deeper into the sand bed than is necessary for quality filtration. The higher the velocity the larger the dirt particles that will be driven through the sand bed. This results in poorer filtration than if the velocity is kept low. Particles that are too deep in the sand bed will be difficult to discharge during backwash. In some cases, the dirt particles are driven through the sand bed and back to the main body of water. This is called channeling. Channeling can occur at lower velocities in some filters than in others. For that reason, we recommend that velocity inside the filter be kept down to 7 FPS. (Figure 19)

Some filters are designed with only a few laterals. This type of filter can be channeled easier than a filter that has more laterals

Example:

2 filters are both flowing 80 GPM. One has 8 laterals and the other has 16. The flow to each lateral in the 8 lateral filter is 10 GPM per lateral. The filter with 16 laterals has a flow to each lateral of 5 GPM. The water is passing through the sand bed in the 8 lateral filter twice as fast as the 16 lateral filter. As a result, the 16 lateral filter will trap more and finer dirt particles than will the 8 lateral filter. The same thing holds true for backwashing the filter. The fewer the laterals, the greater the distance between them. During backwash, the sand directly above each lateral is expanded while leaving dead spots that don’t get cleaned.

Sand Filters and Spas:

There are several possible problems that can occur when using a sand filter with a spa:

1. When backwashing a sand filter, it may require as much as 5 minutes to get the sand bed clean. If the spa is 400 gallons and the pump is flowing 90 GPM, there is not enough water in the spa to backwash the filter.
2. High spa temperatures release body oils that tend to seal the surface of the sand bed. This will cause the filter to cycle very quickly. If not watched closely, resistance can increase to the point that there is little or no flow from the pump, possibly burning up the pump.
3. When it comes to Bacterial Sanitation, it is difficult to ensure uniformity and effectiveness. This can cause pseudomonas or legionella infections in bathers.

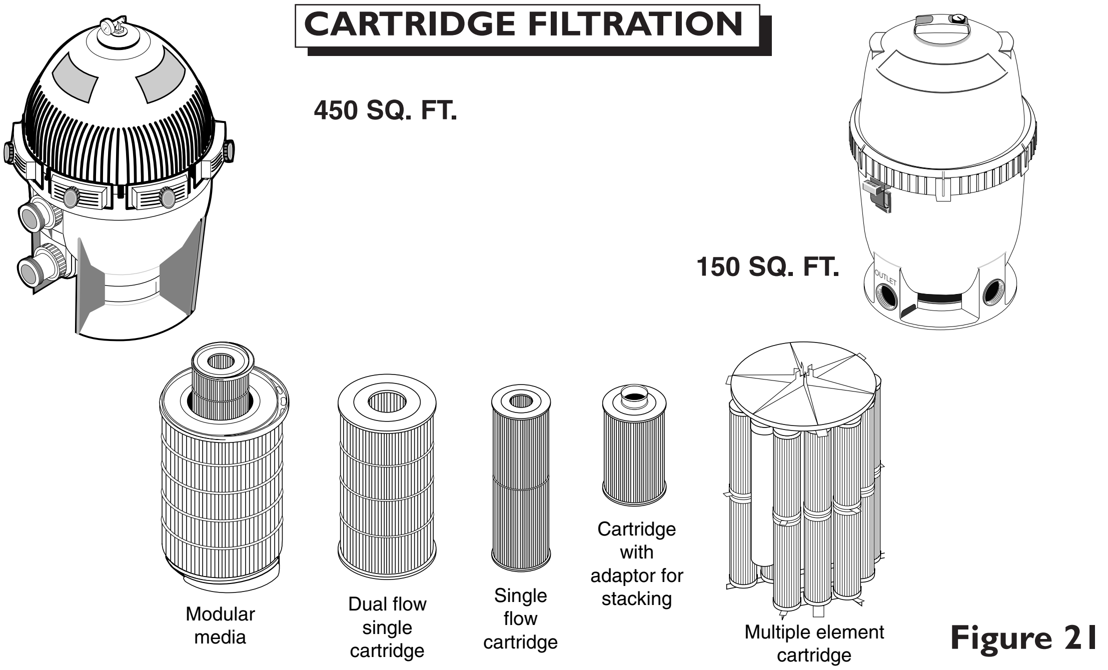


Figure 21

NOTE: Mega cartridge filter sizing charts are located on Page 16 in the Charts and Tables.

Cartridge Filter:

Cartridge filtration is the newest principle to be introduced to the swimming pool, spa, and water feature industries. The compact size gives the designer the option of sizing a large square footage filter in a relatively small tank. As an example; a 75 sq. ft. cartridge filter will occupy half the area on the filter pad as would the same size D.E. or sand filter. The spa industry utilizes the cartridge filter almost exclusively for filtration of pre-plumbed portable spas.

Basic Design of a Cartridge Filter:

Cartridge filter tanks are usually smaller and lighter than D.E. or sand filters. Consequently, more tanks are made of plastic and fiberglass, although stainless steel is used for many of the larger tanks.

The tanks are of various designs depending on the concepts used. There are one piece tanks with threaded or clamped lids. Two piece tanks with clamps are generally used in the larger tanks.

Since these filters are not backwashed, there is no need for gate valves or a backwash valve. As a result the tank's inlets and outlets can be located on different planes, front and back, top and bottom, etc. Many of the filters can be installed in the horizontal position or even upside down. Some of smaller filters are suspended from the plumbing. The larger filters are supported by a base or legs. At, or near the top of the tank is located an air bleed and a pressure gauge.

The internal components of a cartridge filter are the filter elements, an internal air bleed, and in some cases, a top and bottom holding bracket. One of these brackets acts as a manifold for collecting the water from multiple filter elements. Many configurations of filter element designs are used depending on the concept of the designer. There can be one single element or groups of several elements. (Figure 21). Some are stacked end to end to achieve the square footage of the filter.

Some of the newer filters are using one or two very large filter elements in a larger tank. The square footage in these filters is much higher, some as high as 450 square feet, and more. These filters are known as "Mega Cartridges", and are designed to remove a very large amount of dirt from the swimming pool/spa, or water feature before the filter needs to be cleaned. As a result, the cycle time is much longer, in most cases at least a year between cleanings.

CARTRIDGE FILTER - BASIC OPERATIONS

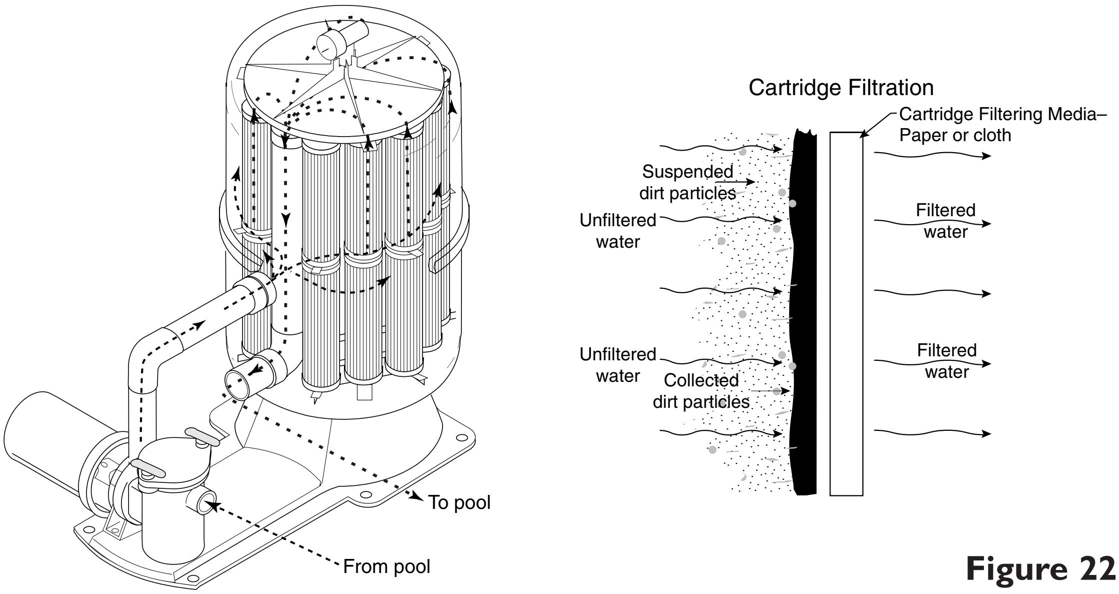


Figure 22

Basic Operation of a Cartridge Filter:

The water containing the suspended dirt particles enters the filter at various points, again, depending on the designer's concepts. The water then passes through the cartridge material depositing the dirt particles on the element. The filtered water exits the cartridge and filter and returns to the main body of water. As more dirt particles accumulate on the filter element, the passageways become restricted. The dirtier the filter gets, the finer it filters, until it reaches a point, usually a 10 PSI increase on the pressure gauge above the original starting pressure, where the filter element is removed and cleaned. (Figure 22).

Velocity and its Effects on Cartridge Filtration:

Of the three types of filters, D.E., sand and cartridge, the cartridge filter is the most sensitive to high velocity. Water at high speed passing through the cartridge element will drive the dirt particles through the filter element and back to the main body of water. It is important to keep the flow down to a minimum. Unlike the D.E. and sand filters, the cartridge filter is not backwashed. There is no minimum flow, so the slower the flow the better the filtration. We recommend that the velocity not exceed 7 FPS, or 1 GPM per sq. ft. of filter area.

The design of the cartridge has a lot to do with the filter cycles and the degree of filtration. A "dual flow" cartridge element will filter finer and give longer filter cycles than will a single filter flow element. By splitting the flow two or more directions slowing down the velocity of the water through the filter element. This allows the filter element to remove finer dirt particles and use more of the element. (Figure 24).

Velocity and the Mega Cartridge Filter:

The design of most Mega Cartridge Filters is a cluster of smaller filter elements. As an example, 4 - 50 sq. ft. filter elements are combined with a common manifold to provide 200 sq. ft. of filter area. By splitting the flow 4 ways, the velocity is very slow as it passes through the filter element. As a result, the filtration will be much better than with a single element. In some of the Mega Cartridges, the velocity is so slow that some of the larger dirt particles never make it to the filter element, they just drop to the bottom of the tank.

The results of the slow velocity through the Mega Cartridges, is that finer filtration is achieved and very long cycles occur as compared to the same size D.E. or sand filters. On a normal residential swimming pool is typical that the filter may go an entire year before it needs to be cleaned.

CLEANING

Figure 23

DUAL FLOW DESIGN

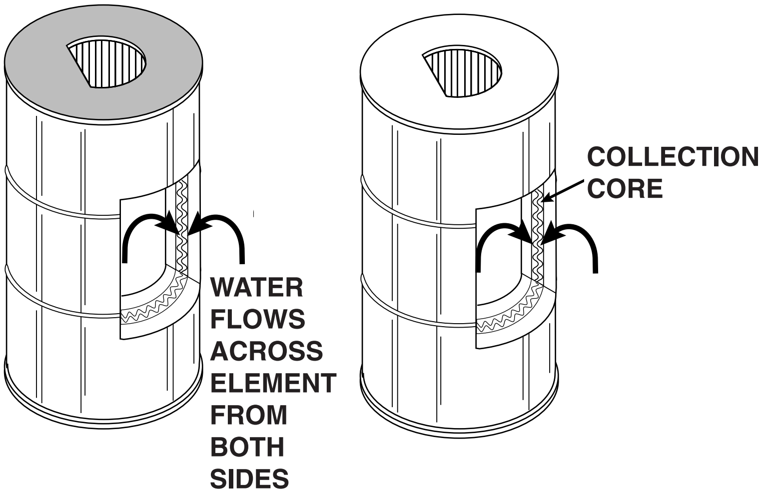


Figure 24

Cleaning the Cartridge Element:

When the pressure gauge has increased 10 PSI over the original starting pressure, it is time to clean the filter element. The element is removed from the filter and simply hosed off. In cases where the velocity has been too high, and the filter is loaded with calcium it should be soaked in a solution of TSP or other filter cleaners. If the pool/spa or water feature has a heavy bather load, there are probably lots of oils and sun tan lotions in the water. We suggest that the pool/spa or water feature use a daily treatment of “Enzymes”. The “Enzymes” are safe to use and will remove these oils. On heavy bather loads, we suggest that the filter element be soaked for a minimum of 24 hrs. in a solution of the Enzymes. About I cup of the enzymes in a barrel of water will be enough to remove the oils. The longer you soak the element the more of the oils that will be removed. (Figure 23).

After the filter is cleaned, the element is returned to the filter and the system is turned back on.

Cleaning a Mega Cartridge Filter:

It takes longer to clean the larger filter elements because these elements collect a lot of dirt over a long period of time. On pools/spas, and water features that have heavy bathing loads there will be large amounts of oils and lotions in the filter element. It will take some soaking and extra time to clean these very large elements.

Cartridge Filters and Spa Applications:

Of the three types of filters used to remove the suspended particles out of spa water, the cartridge filter seems to hold up the best. Because of its compact size, containing a large filtration area, and the fact that it can be installed in tighter areas, the cartridge filter is the most used filter on spas. The D.E. and sand filters are more sensitive to heat and body oils than is the cartridge type filter. The cartridge element is also easier to clean when the filter media is impacted with body oils and calcium.

Dual Filter Systems:

Like the dual element design, installing 2 filters in parallel instead of a single filter will split the flow, slowing down the velocity through the filter element. Two filters installed in parallel will remove more and finer dirt particles, plus extending the filter cycles.

Sizing a Standard Cartridge Filter:

Like the D.E. and sand filter, the cartridge filter should be sized to the GPM that the pump is delivering, rather than what has been calculated as necessary for the turnover rate desired. The recommended flow rate for a cartridge filter is .75 GPM per sq. ft. of filter area for best residential performance.

SIZING

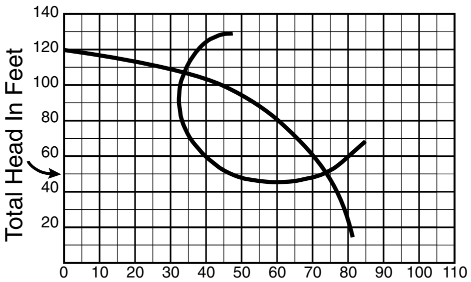
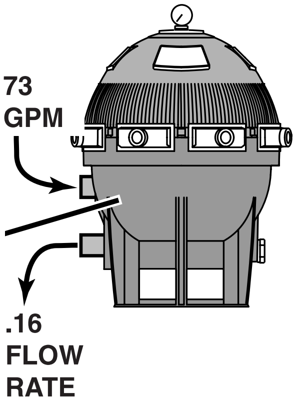


Figure 25

MEGA. CARTRIDGE SIZING



CALCULATING FLOW RATE

35,000 Gallon Residential Pool

8 Hour Turnover = 73 GPM

73 GPM ÷ 450 sq. ft. = .16 GPM
per sq. ft. Filter Area

"MEGA" CARTRIDGE
450 SQ. FT.

Figure 26

Sizing a Standard Cartridge Filter

Example:

15,000 gallon swimming pool that requires an 8 hour turnover rate.

15,000 gal. ÷ 480 min. = 31 GPM
31 GPM ÷ .75 flow rate = 41 sq. ft. filter

Commercial Pools & Spas:

The recommended flow rate for a commercial application is .375 GPM per sq ft of filter area This cuts the flow through the filter in half. We recommend that the velocity be cut even further by using a dual filter system

Exercise:

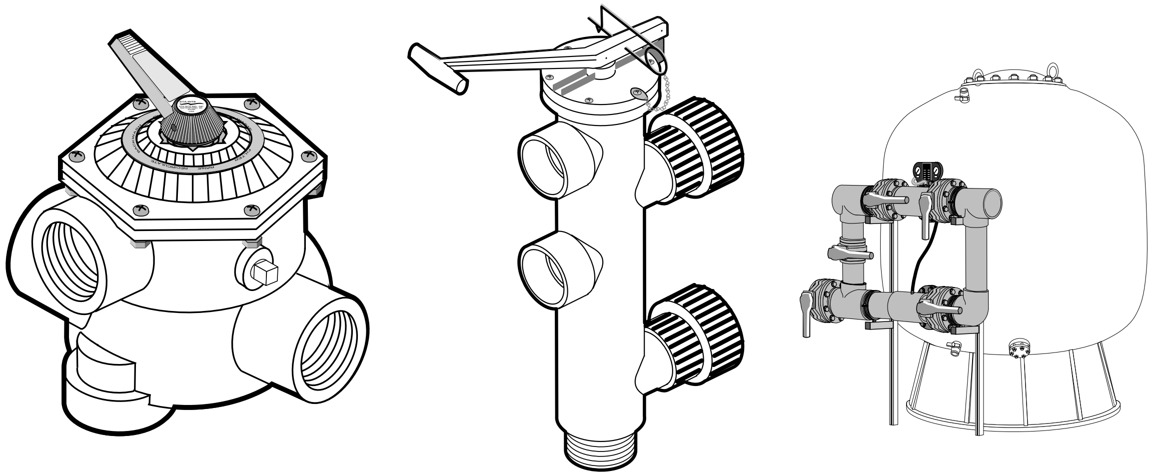
Using the pump curve in Figure 25, for a 2,000 gal. commercial spa. We need 67 GPM for a 30 minute turnover. What size dual cartridge filter would you use?_______

Sizing a Mega Cartridge Filter:

Because of the large square footage of the Mega Cartridge Filter, it can not be sized by a recommended flow rate, like the D.E., sand, or standard cartridge filters. As an example; if we size a 450 sq. ft. Mega Cartridge Filter at a flow rate of 1 GPM per sq. ft. of filter area, as we do with a standard cartridge filter, it would mean that we can flow 450 GPM through the filter. This would require that the inlet, outlet, and internal plumbing would need to be at least 6".

On residential swimming pools, spas, and water features the filter should be sized at flows recommended by the filter manufacturer. The recommended flow rate is usually dictated by the size of the inlet, outlet ports, and the internal plumbing. (Figure 26).

BACKWASH VALVES



MULTI PORT VALVE PUSH PULL VALVE 4 - VALVE BACKWASH

Figure 27

Types of Backwash Valves:

Generally, there are 3 kinds of valves used to backwash a D.E. or Sand System. They are the Multi Port Valve, Push Pull Valve and the 2 way Valves. These valves change the direction of flow in the filters, placing the filter in the "backwash mode".

Multi Port Valve:

The Multi Port Valve is generally used with sand filters. The valve can be connected to the top of the filter or to the side ports, depending on the designers concept of operation. Other than the "Filter and Backwash" positions, the Multi Port Valve has 3 or 4 other settings.

Rinse - Water enters the valve from the pump - through the valve and filter to waste.

Used for initial start-up and to clean and level the sand bed after Back washing.

Closed - This position shuts off flow from the pump to the filter. In this position the pump should be off because the pump is "dead headed".

Used mainly for servicing the system.

Waste - Water enters the valve from the pump and goes directly to waste.

Used for lowering the water level of the main body of water. Also, used to vacuum the pool spa or water feature with out loading the filter bed.

Recirculate - Water enters the valve from the pump and goes directly back to the main body of water, bypassing the filter. Used to recirculate the water with the filter in the plumbing line. In this position the filter can be worked on without shutting off the pump.

Push Pull Valve:

This valve has only two directions. "Filter and Backwash." Generally works on a piston rod that moves up and down, changing the position of 2 or more "Cams". Fully extended in one direction, you are in "filter." Fully extended in the other direction, you are in "backwash."

2 Way Valves:

Usually a group of 4 or 5 valves, depending on the designer's concept. By opening and closing the valves the direction of flow in the filter is changed.

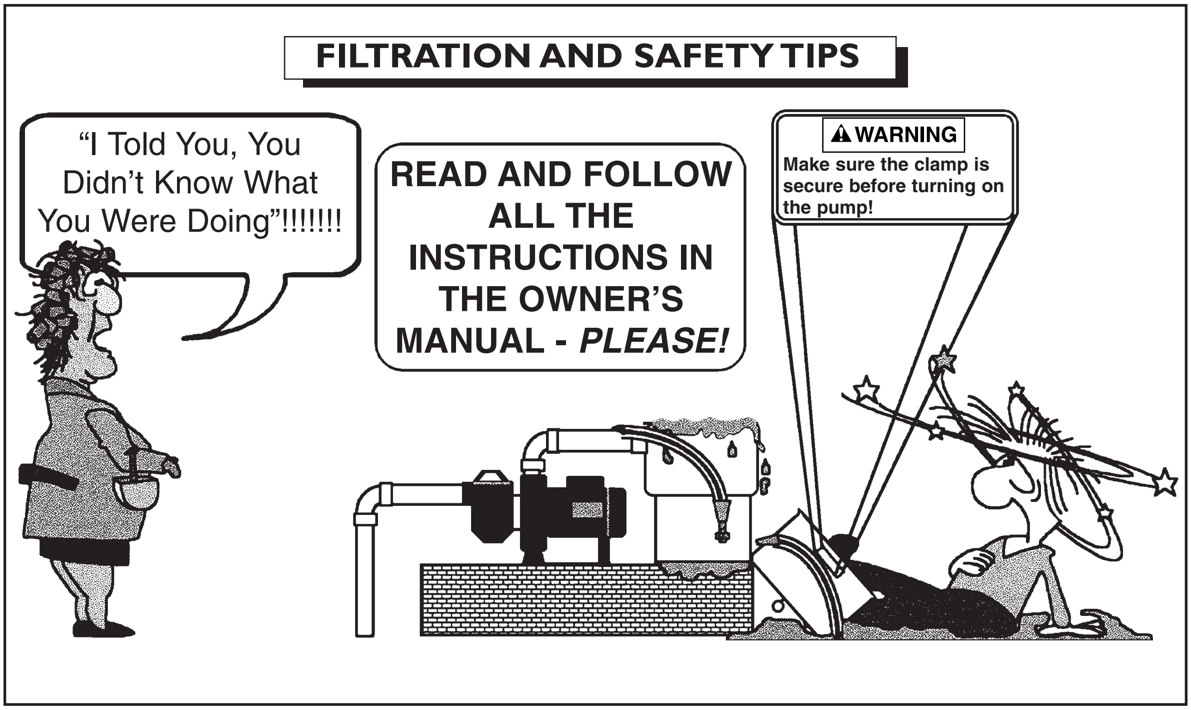
Exercise:

Using the filter at the far right of Figure 27, position the valves for the following chart:

Valves

	1	2	3	4
Filtration				
Backwash				

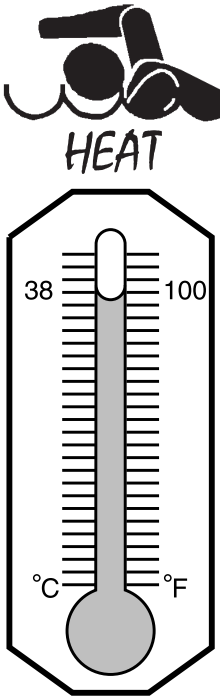
X = Closed O = Open



FILTRATION AND SAFETY TIPS:

1. Good filtration is a direct result of the velocity of the water passing through the filter. High velocity will drive larger dirt particles through the filter media. Higher velocities will generally result in higher system pressures and a shorter life for the filter. Keep the velocity through the filter at, or below 7 FPS.
2. Air, trapped in a filter can compress and cause an improperly adjusted tank clamp to fail. Read the Warning Labels and the Owner's Manual for the proper procedures to follow when removing and replacing the filter lids. Filters equipped with internal air bleeds are designed to remove the continuing build up of air in the tank. The internal air bleed has a screen at the top. This screen needs to be routinely cleaned for proper operation.
3. Valves that are seldom used will take a set on the gasket and the "O" rings. All valves should be taken apart at least once a year and the gaskets and "O" rings inspected and lubricated, or replaced, if needed.

   Note: Valves that are down stream of the filter should not be shut off while the pump is running. This could result in a surge of pressure which could cause an improperly installed filter clamp to fail.
4. Enzymes can help. The regular use of Enzymes in pools, spas, and water features that have heavy loads and or exposed to trees, plants, fields, etc. will remove the oils and other unwanted oils from organic materials. This will extend the filtration cycles and make the filters easier to clean.
5. Separation Tanks - Where used, there should be an isolation valve placed between outlet of the Separation Tank and the return line. After backwashing, the backwash valve(s) are switched to the filter position and the isolation valve is turned to the off position. By doing this the Separation Tank is isolated and not under pressure. If the lid is removed while the system is running, the Separation Tank is not under pressure, and the possibility of an injury is prevented.



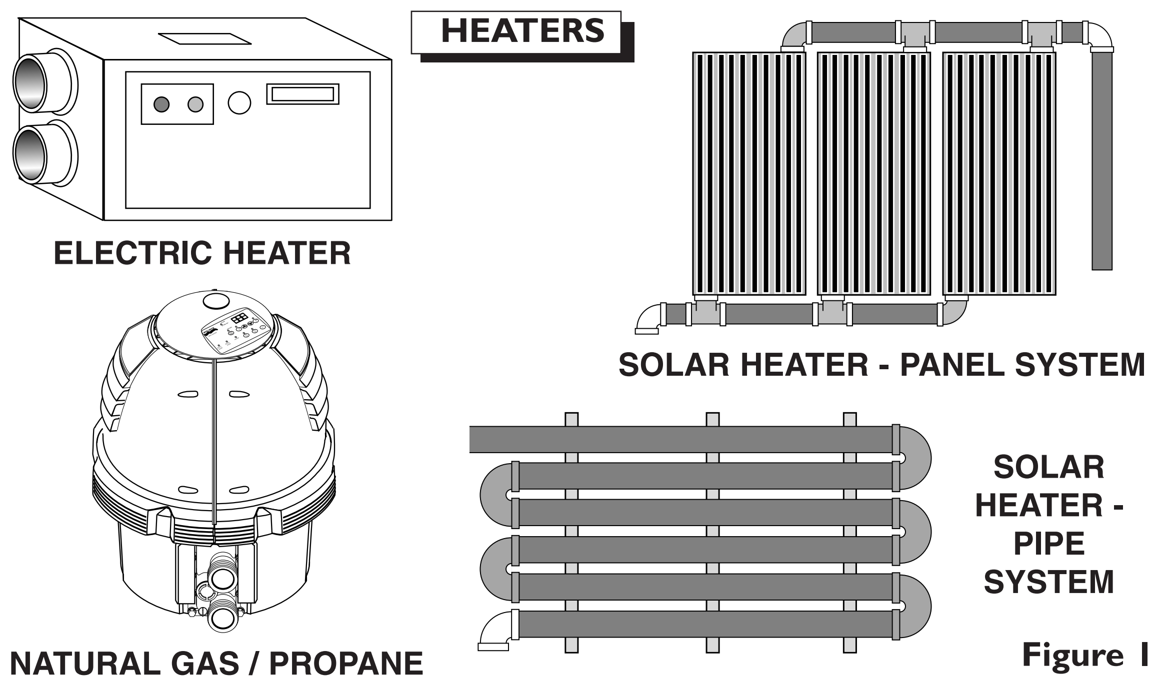


Figure 1

NOTE: Natural Gas/Propane Heater sizing charts are located on Page ## in the Charts and Tables.

Swimming Pool and Spa Heating

Heaters, as used with swimming pools and spas, offer the extended enjoyment and therapeutic effects of swimming and the heated "Jet Action" on the body. Most spas are used all year long. The use of a heater can extend the normal swimming season to the entire year. In any case, the heater is a necessity for a spa and a helpful addition to a swimming pool.

Types of Heating

There are several types of heating devices in use for swimming pools and spas. We will cover 3 of these: (Figure 1)

- **Electric**
- **Natural Gas or Propane**
- **Solar**

The others are Heat Pumps and Oil Fired Heaters. These types of heaters are effective, but not in great use.

Energy Efficiencies and the Pool and Spa Heater

Since the majority of the heat loss is due to the exposed surface of the water, it is good practice to keep the swimming pool and spa covered. A cover can save as much as 75% of the heat loss due to the lower temperature of the surrounding air. It is particularly important with spas that are kept at the desired temperature year round.

Other variables are the wind, altitude, and sheltered or shady areas

Wind - A constant wind can remove heat from the swimming pool or spa at a greater rate. The higher the wind velocity the more heat is removed. If there is a constant wind that is greater than 10 miles per hour, you should add at least 25% to the size of the heater. (Figure 2)

Example:

A swimming pool requires a heater that is rated at 300,000 BTU's. There is a consistent wind of 13 MPH. The heater size should be increased to at least a 375,000 BTU heater, or larger.

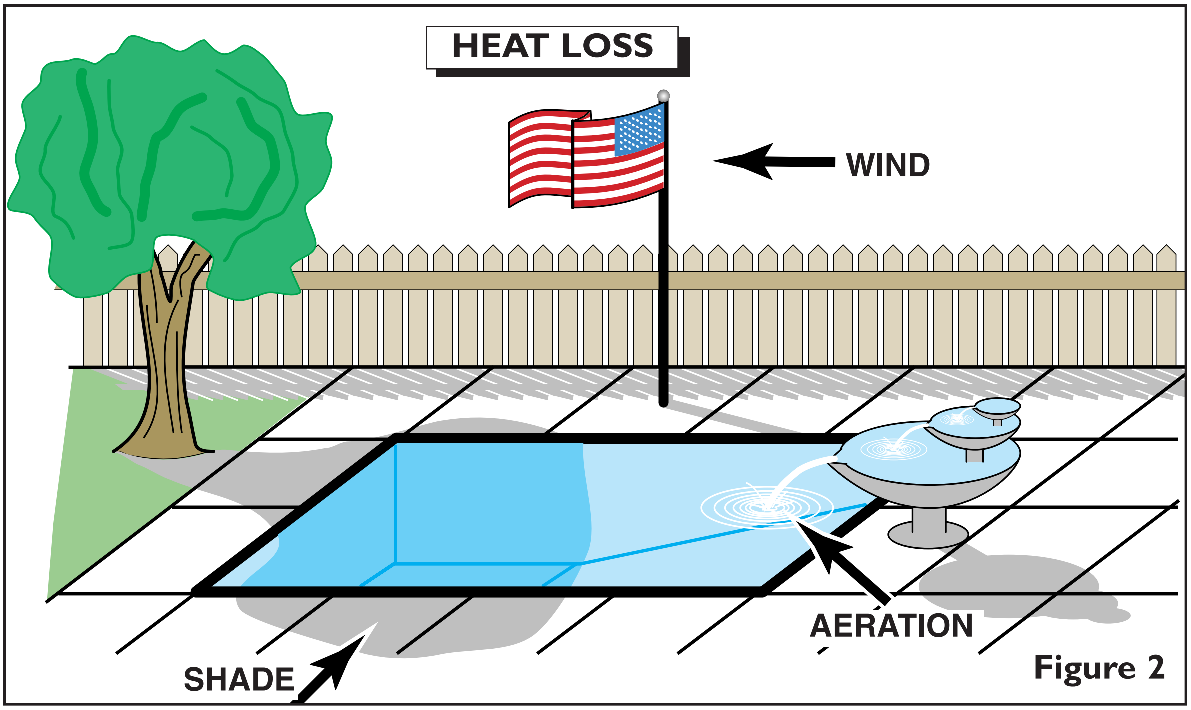


Figure 2

Shade - In pools or spas constructed in an area shaded from the heat of sun, the heater size should be based on the temperature of the shaded area. This temperature can be as much as 20° below the sunny areas. (Figure 2)

Aeration - Waterfalls, fountains, and spa jets have an effect of cooling the water faster than the normal cool down by the surrounding ambient air temperature. When sizing a heater, keep in mind that these features will extend the time it takes to heat a pool or spa. Efforts should be taken to turn off these features during the heat up time. (Figure 2)

Altitude - Due to the reduction in atmospheric pressure as you gain altitude, it takes longer to heat the water. A rule of thumb is to increase the size of the heater about 4% for each 1,000 feet in elevation.

Example:

A swimming pool that requires a 200,000 BTU heater is located at an altitude of 5,000 ft. To compensate for the lower atmospheric pressure, the heater size needs to be increased 4% for each 1,000 ft.

(4% x 200,000) x 5 = 40,000 BTU
Heater size needs to be 240,000 BTU or larger.

Problem:

A spa that is installed outside of a penthouse on top of a 60 story building. The altitude is 750 feet and there is a constant 12 MPH wind blowing. The spa is continually heated and has been sized for a 300,000 BTU Heater. Due to altitude and the wind conditions.

What is the size of the heater you will recommend?

_______________ BTU

Pool and Spa Temperatures

Swimming Pools - The American Red Cross recommends that the average temperature range be from 78° to 82° Fahrenheit (26° to 28° Centrigade).

Spas and Hot Tubs - The National Spa and Pool Institute recommends that the temperature in a spa or hot tub should not exceed 104° Fahrenheit (40° Centigrade).

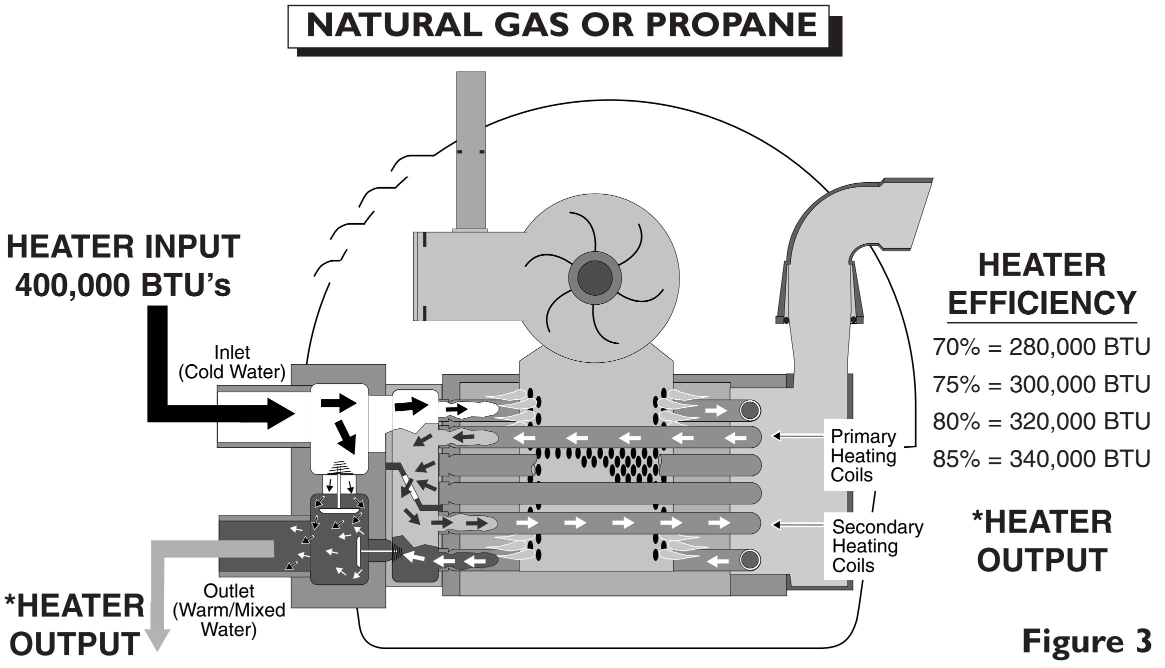


Figure 3

Natural Gas or Propane Heaters

These type of heaters are the most commonly used with swimming pool and spas. They are called direct fired heaters. A direct fired heater burns fossil fuels. Water flowing through the exchanger is heated by the heat produced by the burning process. The exhaust must be vented to the outside atmosphere or reburned.

Heater Ratings and Efficiencies

Most of the heaters used for swimming and spa systems range from 100,000 BTU to 500,000 BTUs. A BTU is a unit of measurement. A British Thermal Unit is how we size these heaters. One BTU can raise one pound of water one degree Fahrenheit.

The heater is rated by the input BTUs per hour. The output BTUs are the amount of energy transferred to the water. The ratio of the input to the output BTUs is shown as the efficiency of the heater. (Figure 3)

Basic Operation of a Natural Gas or Propane Heater

Water, usually after it passes through the filter(s), enters the heater through the inlet fitting. In some heaters the inlet and outlet are plumbed with a heat sink. The heat sink is made of metal, copper or stainless steel. The purpose of the heat sink is to absorb the high temperature in the water and cool it down enough so that the rest of the plumbing can be PVC. Most heater manufacturers that require heat sinks recommend at least a 3 foot run on the inlet and outlet side of the heater. In some cases they recommend a check valve between the heater and the filter. When the system shuts off, hot water can't backflow from the heater to the filter causing distortion of the filter's plastic parts.

Once inside the heater some of the water is by-passed. Heaters are designed to operate at a predetermined flow rate, normally not exceeding 100 GPM. Any excess flow is diverted to the outlet side of the heater. The bypass valve is a spring loaded valve that opens when the pressure indicates that there is too much flow.

The water now enters the heat exchanger. The heat exchanger is a series of copper finned tubes that absorb the heat from the combustion chamber and transfer it to the water.

After passing through the heat exchanger, the water exits the heater and returns to the pool or spa. (Figure 3)

BASIC HEATER COMPONENTS

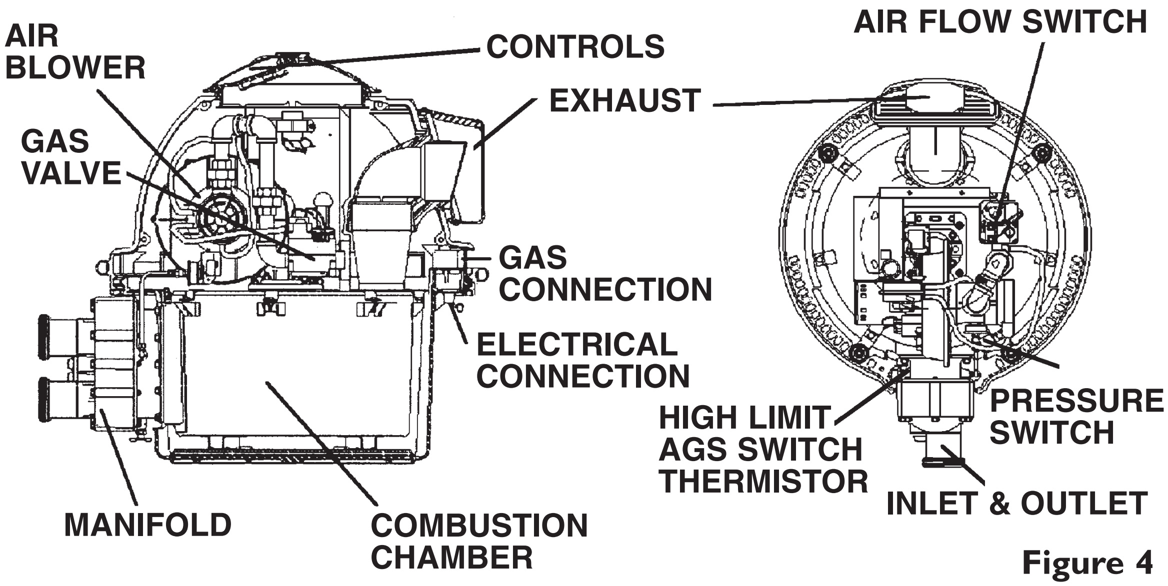
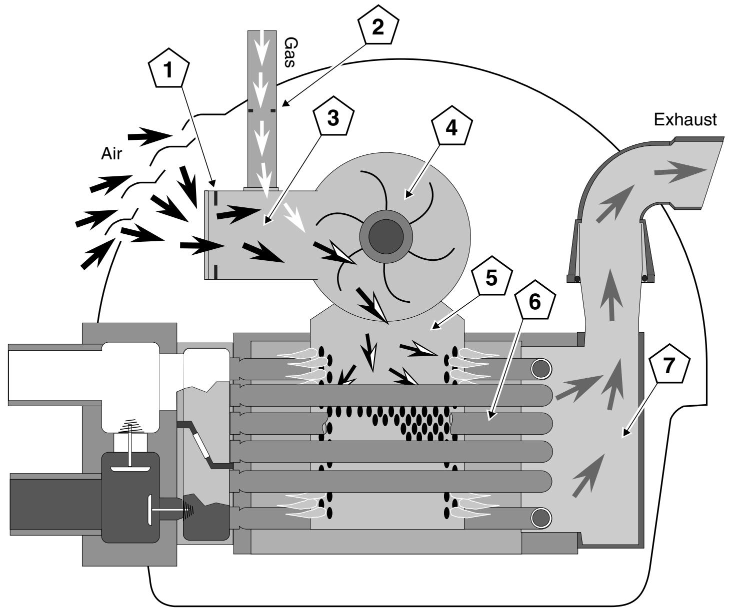


Figure 4

Basic Heater Components

1. The **Thermistor** senses the inlet water temperature.
2. If the temperature sensed is lower than that set on the **Operating Control**, power is supplied to the **Ignition Control Module** through a series of safety interlocks.
3. The **Water Pressure Switch** senses whether or not the pump is running.
4. The **High Limit Switch** monitors the outlet water temperature and will open if a malfunction causes the outlet temperature to reach 135˚F.
5. The **Automatic Gas Shutoff Switch (AGS)** monitors the outlet temperature from the Heat Exchanger and will open if a malfunction causes the water outlet temperature to reach 150˚F.
6. If the High Limit Switch and the Water Pressure Switch are OK, the **Ignition Control Module** starts the **Combustion Air Blower**.
7. When the Blower comes up to speed the **Air Flow Switch (AFS)** senses air flow across the Air Metering Orifice.
8. If the airflow is sufficient, the AFS closes, completes the ignition circuit, and supplies power to the **Ignition Control Module**.
9. In 20 seconds the **Hot Surface Ignition (HSI)** element heats to ignition temperature. The **Combination Gas Control Valve** then opens and the burner flame ignites.
10. If the burner does not ignite in seven seconds, the system shuts down and locks itself out. Power to the system must be turned off and turned back on again before it will start.
11. The HSI element automatically switches from ignition mode to a flame sensing mode to monitor the flame.
12. The Burner in the **Combustion Chamber** fires until the desired water temperature is reached. Once reached, the Burner shuts off and the Blower continues to run for about 45 seconds (known as “post purge”).
13. If the flame is extinguished during operation, the **Combination Control Gas Valve** closes and the ignition cycle reactivates.
14. If any safety interlocks open during Burner operation, the Burner immediately shuts off, but the Blower continues to run for about 45 seconds.

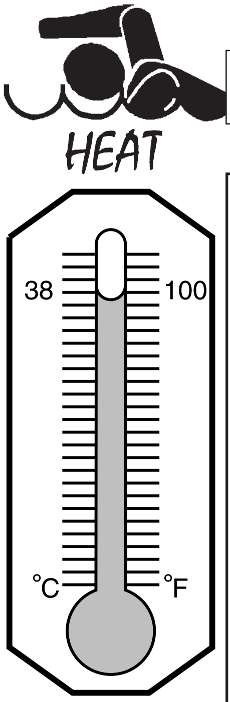


GAS AND AIR FLOW THROUGH THE HEATER

Figure 5

Gas and Air Flow Through the Heater

1. The Blower draws ambient air into the Burner System by negative pressure through the **Air Orifice**.
2. The Blower at the same time is drawing Natural or LP Gas into the Burner System by negative pressure through the **Gas Orifice**.
3. The air and gas are thoroughly mixed in the **Mixing Tube**.
4. The **Blower** then forces the air/gas mixture into the **Combustion Chamber** under a slight positive pressure.
5. The mixture is ignited in the **Combustion Chamber**, around the circumference of the **Flameholder**. Combustion continues until the pre-set water temperature is reached.
6. The **Heat Exchanger** tubes surrounding the Burner extract heat from the hot flue gases and heat the water flowing through the tubes.
7. The cooled exhaust is collected in a sealed Exhaust **Plenum**, then is discharged out the flue.



HEATER SIZING

POOL HEATER SIZING CHART (24 Hr. Period)

Pool Size Sq. Ft.	Temperature Rise 10°	15°	20°	25°	30°
200	55,900	83,800	111,840	139,800	167,760
300	83,880	125,820	127,700	209,700	251,640
400	111,850	167,775	223,700	279,625	335,550
500	139,810	209,715	279,620	349,525	419,430
600	167,770	251,655	335,540	419,435	503,310
700	195,720	293,595	391,460	489,325	587,190
800	223,690	335,535	447,380	559,225	671,070
900	251,650	377,475	503,300	629,125	754,950
1,000	279,610	419,415	559,220	699,025	838,830

Heat Loss = Required Heater Output (BTUs/Hour)

Note: Chart prepared by the Commercial Water Heating Sub-committee of the American Gas Association in Oct. 1995.

Figure 6

POOL MAINTENANCE HEATER SIZING CHART

(Outdoors, 3.5 mph Wind)

Pool Size Sq. Ft.	Temperature Rise 10°	15°	20°	25°	30°
200	21,000	31,500	42,000	52,500	63,000
300	31,500	47,300	73,000	78,800	94,500
400	42,000	63,000	84,000	105,000	126,000
500	52,500	78,800	105,000	131,000	157,000
600	63,000	94,500	126,000	157,000	189,000
700	73,400	110,000	147,000	184,000	220,000
800	84,000	126,000	168,000	210,000	252,000
900	94,500	142,000	189,000	236,000	284,000
1,000	105,000	157,000	210,000	263,000	315,000

Heat Loss = Required Heater Output (BTUs/Hour)

Note: Chart prepared by the Commercial Water Heating Sub-committee of the American Gas Association in Oct. 1995.

Figure 7

Initial Heat Up Time

Figure 6 is an easy way to size a Heater for a swimming pool. Simply determine the surface area square footage and the desired temperature. Then refer to the chart for the amount of BTUs required to heat up the swimming pool.

Example:

A 400 sq. ft. pool with a Temperature rise of 20 degrees. The Heater Output per Hour needs to be at least 223,700 BTUs to heat up the swimming pool in 24 hours.

To calculate the heat up time, use the following formula.

Pool Gallons x 8.33 (the weight of 1 gal of water) x Temp. Rise = Output BTUs needed to achieve desired water temp. in a 24 hour period.

Example:

20,000 gal. pool with a 20° temperature rise
20,000 x 8.33 x 20 = 3,332,000 Output BTUs needed. 3,332,000 ÷ 24 hours = 138,833 BTU Heater.

If a heater has already been selected, the heat up time can be determined using the same formula and dividing the required BTUs to heat up the pool or spa in 24 hours by the Output BTUs of the heater.

Example:

Using the previous example, the number of BTUs required to heat up the swimming pool in 24 hours is 3,332,000 BTUs. Divide this number by the Output BTUs of the chosen Heater.

3,332,000 ÷ 340,000 BTU = 9.8 hrs.

To maintain the heat in normal conditions, use the chart in Figure 7 Using the above example, it would take 84,000 BTUs per hour to maintain the desired temperature.

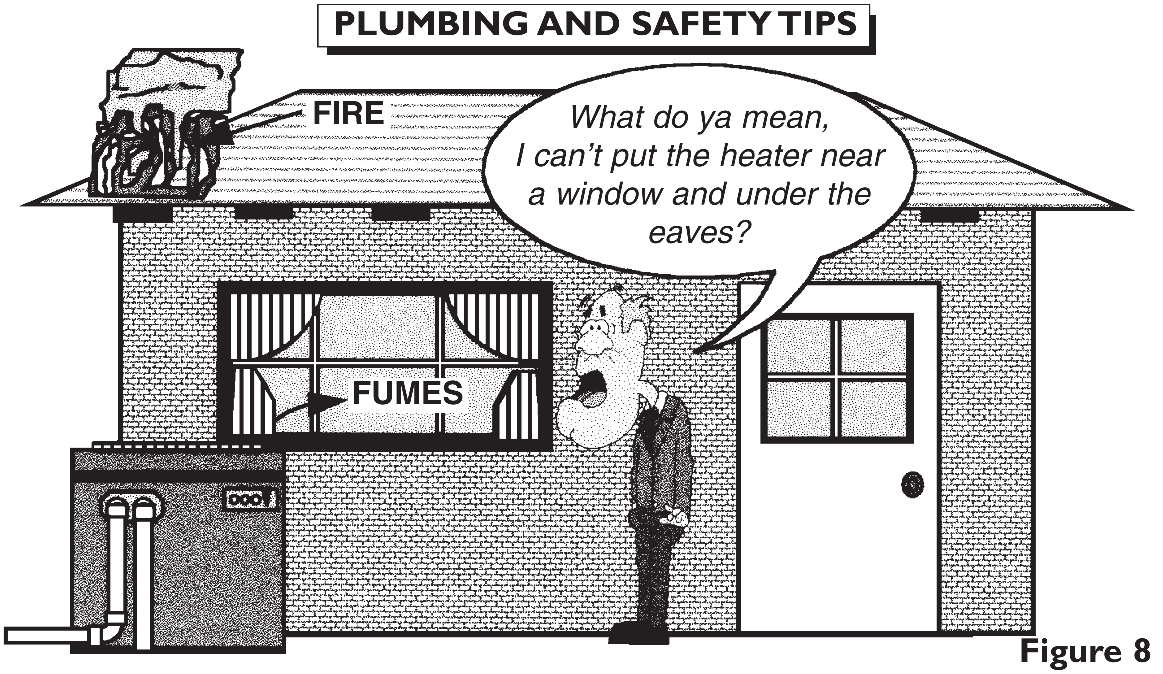
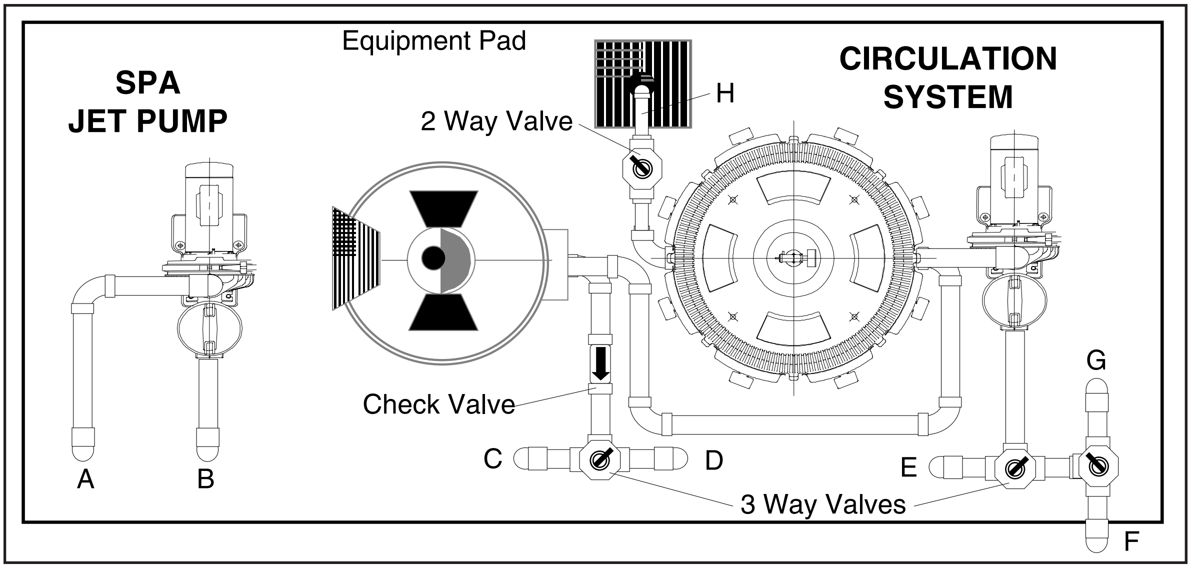


Figure 8

Plumbing and Safety Tips

1. Leave access room around the heater for maintenance.
2. Comply with local codes when installing heaters. If there are no local codes, install in accordance to the National Fuel Gas Code, ANSI Z223.1 and the National Electrical Code.
3. Install a check valve between the heater and any Chlorinating Device that is down stream of the heater.
4. Heaters installed too close to combustible surfaces may cause a fire. (Figure 8)
5. Check the Heater Owner's Manual. The heater may require a check valve between the heater and the filter.
6. **⚠ DANGER** Heaters running on LP gas. LP gas is heavier than air and can settle in low places. This is a life hazard and a explosion hazard.
7. Flex gas connections can restrict the gas supply and affect the performance of the heater.
8. Be careful when designing an external by-pass to divert excess flow around the heater. It is possible to dead head the flow on both sides of the heater. The pressure switch may still sense pressure and allow the heater to fire.



A - **To the Spa Jets**
B - **From Spa Dual Main Drains for Safety**
C - **Return to Spa Deep Heat Return(s)**
D - **2” to Pool Returns**
E - **From Spa Dual Main Drains**
F - **From Pool Skimmer(s)**
G - **From Dual Main Drains**
H - **1-1/2” to Maintenance Drain**

Basic Spa Equipment and Piping Specifications

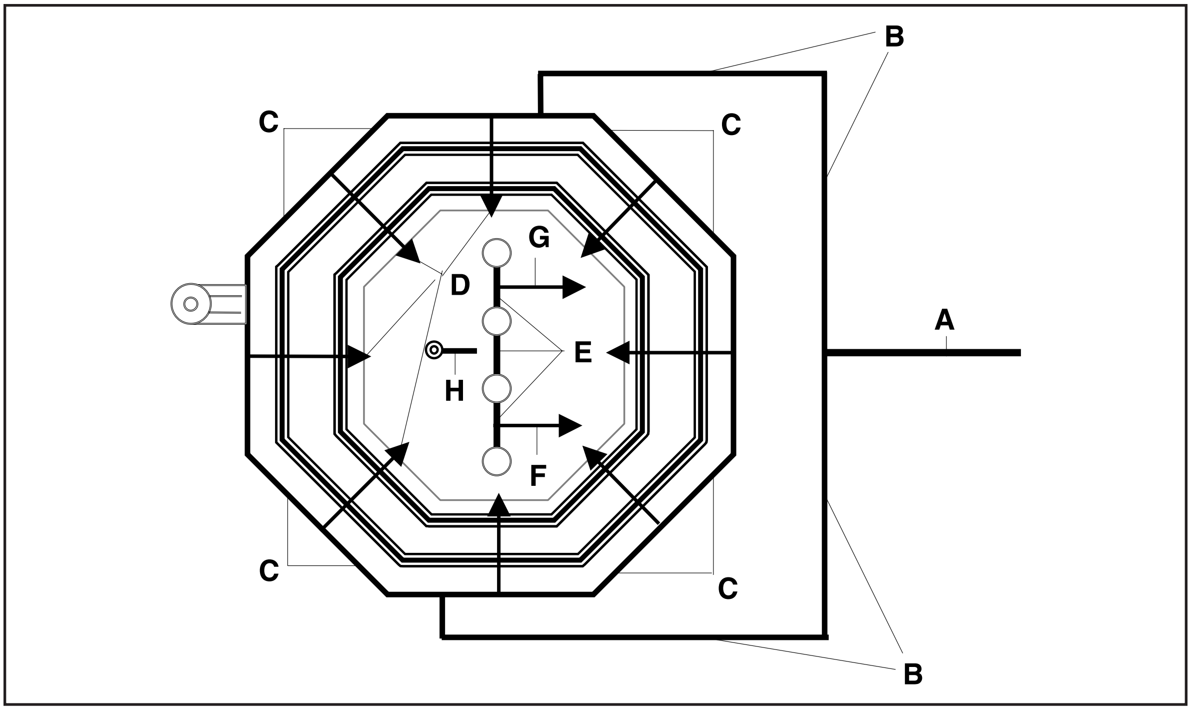
CIRCULATION SYSTEM											JET PUMP			
							Pipe Sizing						Pipe Sizing	
Pool Gallons	Pump HP	Mod Filter	Sand Filter	D.E. Filter	Heater	C	D	E	F	G	No. of Jets	Pump HP	A	B
20,000	1/2	150+	2.4+	37+	200,000+	1-1/2”	1-1/2”	1-1/2”	1-1/2”	1-1/2”	4	3/4	1-1/2”	1-1/2”
27,000	3/4	150+	3.4+	53+	333,000+	2”	2”	1-1/2”	1-1/2”	1-1/2”	5	1	2”	2”
35,000	1	300+	4.9+	53+	333,000+	2”	2”	2”	2”	1-1/2”	6	1-3/4	2”	2-1/2”
44,000	1-3/4	300+	(2) 3.4+	53+	400,000+	2”	2”	2-1/2”	2-1/2”	1-1/2”	7	1-1/2	2”	2-1/2”
48,000	1-1/2	450	(2) 4.9+	53+	400,000	2”	2”	2-1/2”	2-1/2”	1-1/2”	8	2	2-1/2”	2-1/2”
56,000	2	450	(2) 4.9+	83	400,000	2-1/2”	2-1/2”	2-1/2”	2-1/2”	1-1/2”	9	3	3”	3”
67,000	3	(2) 300+	(2) 4.9+	83	(2) 333,000+	3”	3”	3”	3”	1-1/2”	10	3	3”	3”

Circulation System Notes:

1. Pumps sized at 60 foot of head for an 8 hour turnover rate.
2. Filters sized at best flow rates. + = O.K. to increase filter size.
3. Pipe sizing based on 7 fps or better.
4. Multiple pump and filter systems can be substituted for single systems.
5. If spa is elevated, place a check valve on line “C”.

Jet Pump Notes:

1. Pumps sized at 40 foot of head.
2. High Head or Medium Head pumps can be used. Pipe runs of 35 feet or more, use High Head pump.
3. Spa jets calculated at 15 gpm each.



1. **Spa gallons – 800 gallons**
2. **30 minute turnover = 27 GPM**
3. **Pipe "A" – From Spa Jet Pump - Full Flow**
4. **Pipe "B" – Half Flow Manifold to Spa Jet Loops**
5. **Pipe "C" – Spa Jet Loop**
6. **Pipe "D" – Spa Jets**
7. **Pipe "E" – Main Drain Manifold**
8. **Pipe "F" – Suction Pipe from Dual Main Drain to Spa Jet Pump**
9. **Pipe "G" – Suction Pipe to Circulation System**
10. **Pipe "H" – Deep Heat Return(s) from Filter System**
11. **Skimmer – 2" to the Pump**

Spa Jet Hydraulics – Balanced Hydraulic Design

Spa Jet Orifice	GPM Per Jet	Total GPM	Pipe Sizing							
			A	B	C	D	E	F	G	H
1/4"	7	56	2"	1-1/2"	1-1/2"	1-1/2"	2"	2"	1-1/2"	1-1/2"
5/16"	11	88	2"	1-1/2"	1-1/2"	1-1/2"	2"	2-1/2"	1-1/2"	1-1/2"
3/8"	15	120	3"	2"	2"	1-1/2"	2"	3"	1-1/2"	1-1/2"
7/16"	19	152	3"	2"	2"	1-1/2"	2"	4"	1-1/2"	1-1/2"
1/2"	25	200	4"	2-1/2"	2-1/2"	1-1/2"	2-1/2"	4"	1-1/2"	1-1/2"

Orifice Size for Gunite or Portable Spas.
All Jet Sizing at 15 gpm.
All Suction Piping sized at 6 fps or better.
All Return Piping sized at 8 fps or better.
Piping will need to be adjusted for runs of 50' or more.

Basic Swimming Pool Worksheet:

Pool Specifications:

Square Footage ________
Cubic Feet ________
Average Depth ________ Ft.
Pool Gallons ________
8 Hr. Turnover Rate ________ GPM

Pipe, Fittings, Lights:

Number of Main Drains ________
Number of Skimmers ________
Number of Returns ________

Main Drain to Pump
Pipe Size ________
Skimmer to Pump
Pipe Size ________
Filter System to Returns
Pipe Size ________

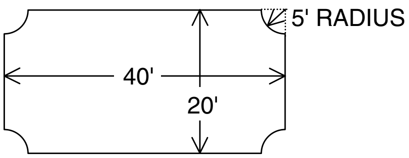
Number of Lights ________

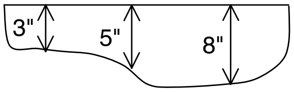
Other Equipment ________
____
____
____

System Head Loss:

Main Drain Head Loss ________ Ft.
Skimmer Head Loss ________ Ft.
Return Piping Head Loss
Section I ________ Ft.
Section II ________ Ft.
Section III ________ Ft.
Static Suction Lift ________ Ft.
Filter/Heater
System Head Loss ________ Ft.

Total System Head Loss = 15.40′





Equipment Pad

Filtration and Heating System:

Circulation Pump ________ HP
Motor Voltage ________
Max. Load Amps ________
Breaker Size ________ AMP
Wire Size No. ________ AGW
High Rate Sand Filter ________ Sq. Ft.
Filter Flow Rate ________ fps
Amount of Sand ________ Lbs.
Diatomaceous Earth Filter ________ Sq. Ft.
Filter Flow Rate ________ fps
Amount of D.E. ________ Lbs.
Cartridge Filter ________ Sq. Ft.
Filter Flow Rate ________ fps
Modular Media Filter ________ Sq. Ft.
Filter Flow Rate ________ fps
Back Wash Valve Type ________
Heater Type ☐ NA
☐ LP
Heater Size ________ BTU
Gas Line Size ________ Inches

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