PUMP & FILTER
SIZING FOR YOUR POOL

Hydraulics and the Basics of Pump/Filter Sizing

Hydraulics is the study and understanding of the behavior of liquids at rest and in motion. In this situation, we are considering the following characteristics:

- How much water do we have (pool capacity)?
- How fast can we safely move the water (Turnover Rate and Water Velocity)
- How much resistance will this water meet while moving through the system (Friction Loss)?
- How will we overcome this resistance (Pump/Filter Sizing)?

Below are step-by-step instructions to answer these 4 questions and ultimately determine the proper pump and filter size for virtually any pool installation.

1. Pool Capacity

To determine total gallons, we must first calculate the surface area of the pool in square feet:

A) Surface Area

For Freeform Pools: Area = (A+B) x L x 0.45
For Round Pools: Area = R x R x 3.14
For Rectangle Pools: Area = L x W

________________ ft^2
(surface area)

Example: Surface Area = 16 ft x 32 ft = 512 ft^2

Next, multiply the surface area by the average depth to determine the appropriate volume of the pool.

B) Average Depth

(______________ ft + ______________ ft) ÷ 2 = __________ ft
depth, shallow end | depth, deep end | average depth

Example: Average Depth = (3 ft + 8 ft) ÷ 2 = _________ ft

C) Volume

(______________ ft + _____________ ft) ÷ 2 = _________ ft
surface area average depth volume

Example: Volume = 512 ft^2 x 5.5 ft = 2816 ft^3
Next, multiply the pool's volume in ft3 by 7.5 to get the pool capacity in gallons. Some of the more common pool sizes are:

Above Ground Size	Gallons*
15 ft Round	5,293
18 ft Round	7,622
21 ft Round	10,374
24 ft Round	13,550
12 x 24 ft Rectangle	8,626
27 ft Round	17,149
* Average Depth of 4 Ft	

Inground Size	Gallons*
12 x 24 ft Rectangle	11,861
16 x 32 ft Rectangle	21,086
18 x 36 ft Rectangle	26,687
20 x 40 ft Rectangle	32,947
* Average Depth of 5.5 Ft	

2. Flow Rate

While the actual flow rate of a pump is based on the total resistance of the system as described below, the desired flow rate must be calculated to verify it will satisfy Turnover Rate and Water Velocity requirements.

A) Turnover Rate

The turnover rate for a swimming pool is the amount of time required to circulate the entire volume of water through the system once to meet reasonably clean, safe water standards.

Based on the pool's capacity and the desired turnover rate, the minimum rate at which the water must be circulated in Gallons Per Minute (GPM) is calculated as follows:

A. Minimum Flow in Gallons per Hour (GPH)

_____________ Gallons ÷ _____________ hours = _______________ GPH
pool capacity desired turnover rate minimum flow, gallons per hour

Example: Minimum Flow = 21,120 Gallons ÷ 10 hours (assumed) = 2,112 Gallons Per Hour

B. Minimum Flow in Gallons per Minute (GPM)

______ Gallons Per Hour ÷ 60 Minutes Per Hour = _______ GPM
minimum flow, GPH minimum flow, gallons per minute

B) Water Velocity

The maximum recommended water velocity is 6 or 8 feet per second for suction lines and 10 feet per second for return lines. The table below lists the maximum flow in GPM based on plumbing size and water velocity.

Maximum Flow

Pipe Size	6.0 ft/sec	8.0 ft/sec	10.0 ft/sec
1 1/2”	38 GPM	51 GPM	63 GPM
2”	63 GPM	84 GPM	105 GPM
2 ½”	90 GPM	119 GPM	149 GPM
3”	138 GPM	184 GPM	230 GPM

Example: Maximum Flow = 2” suction side plumbing at 6.0 ft/sec = 63 GPM

C) Desired Flow

The desired flow rate must be between the minimum flow based on the Turnover Rate and the maximum flow based on the Water Velocity. Notet hat if higher flow rates are needed, such as for water features, the maximum possible flow would have to be increased by using larger size plumbing (example: increase from 2” to 2 ½” plumbing). The use of branch (parallel) plumbing can also be used to reduce the flow and therefore plumbing size.

It is recommended to select a flow that is higher than the minimum to account for decrease in flow that naturally occurs as the filter is loaded with dirt and debris.

Example:

Minimum Flow (Turnover Rate) : 35 GPM
Maximum Flow (Water Velocity) : 63 GPM
Desired Flow: 50 GPM

3. Friction Loss

Everything that the water must pass through within the circulation system – plumbing and equipment – creates resistance or Friction Loss. The friction loss for standard plumbing supplies such as pipe, elbows, fittings, etc can be found using published reference tables. Friction loss for equipment such as filters, heaters, and chlorination systems can be found in charts and/or curves provided by the manufacturer. The sum of all the resistance is called the Total Dynamic Head (TDH) and is typically measured in Feet of Water or Feet of Head.

A properly sized pump will have the ability to overcome the Total Dynamic Head of the system, while, at the same time, providing flow that will satisfy Turnover Rate and Water Velocity Requirements. For new installations, it is possible to calculate TDH by using reference tables and manufacturer's data to determine the friction loss associated with every component in the circulation system.

For existing installations, we are often unable to determine the total amount of pip and fittings, as they can be buried underground. Therefore, what follows is a rule of thumb means of determining Total Dynamic Head.

We will need to add the resistance from the vacuum (suction) side of the existing pump to the resistance of the pressure side of the pump. Note that this assumes the Static Suction Lift (ie. the vertical distance from the center of the pump's impeller to the surface of the water) is offset by the water returning to the pool.

A) Friction Loss (Vacuum)
________ inches of mercury x 1.13 ft of water = ________________ ft of water
vacuum reading total resistance, vacuum

Typically, however, a vacuum reading will not be available, therefore, the table below provides Common Head Loss Factors for today's high-efficiency pumps.

Pump Size	Head Loss Factor*
¾ H.P.	4.5 to 5.5 ft of Water
1 H.P.	7 to 9 ft of Water
1 ½ H.P.	10 to 12.5 ft of Water
2 H.P.	13.5 to 16 ft of Water

Assumes 2" suction line, not to exceed 40 ft long, minimal fittings, one (1) 2" valve and full-rated pumps.

Example: Total Resistance (Vacuum) = 9 ft of water (existing 1 H.P. Pump)

B. Friction Loss (Pressure)
______________ PSI x 2.31 ft of water/ PSI = _________________ ft of water
filter pressure, clean total resistance, pressure

Example: Total Resistance (Pressure) = 10 PSI / 2.31 ft of water / PSI = 23 ft of water

C. Total Dynamic Head

_________ ft of water + ___________ ft of water = _____________ ft of water

total resistance, vacuum   total resistance, pressure   total dynamic head

Example: Total Resistance (Pressure) = 10 PSI / 2.31 ft of water / PSI = 23 ft of water

4. Pump Sizing

We now have all of the information necessary to select the proper size pump and/or filter and then proceed based on new vs. existing installations.

A pump's performance data is provided in GPM (output) vs. Feet of Head (resistance). The specific performance data for our wide selection of pool pumps can be found on our website, www.PoolSuppliesCanada.ca.

A) Pump Sizing (New Installations)

For new installation, use the desired flow rate and Total Dynamic Head calculated from tables and manufacturer's data:

Desired Flow = _______________ GPM

Total Dynamic Head = _________________ ft of Water

Using the pump performance curve / data table, identify which pump's performance comes closest to matching the point where the Desired Flow intersects with the Total Dynamic Head.

B) Pump Sizing (Existing Installations)

For existing installations, use the Total Dynamic Head calculated from the Friction Loss on the Vacuum and Pressure side of the pump.

Total Dynamic Head = ________________ ft of water

Using the manufacturer's performance curve for the existing pump, find the flow that corresponds to the Total Dynamic Head. This is the actual flow at which the pump is currently operating, which may or may not meet Turnover Rate and Water Velocity requirements. Verify the actual flow rate is between the minimum flow based on the Turnover Rate and the maximum flow based on the Water Velocity.

Example: Total Dynamic Head = 32 ft of water

If the actual flow rate does not meet the Turnover Rate and Water Velocity requirements, you must either modify the system to add or remove restrictions (example: use less restrictive plumbing fittings and/or equipment) or vary the flow by changing the pump.

Important: if you increase or decrease the flow for any reason (example: change pump size), Friction Loss will increase or decrease respectively. You cannot read horizontally across the curve at the same Total Dynamic Head to choose another pump. You must create a system curve based on the following relationship:

________ ft of water x (______ GPM ÷ _______GPM)^2 = ________ ft of water
current friction loss new flow rate current flow rate new friction loss

Choose the minimum and maximum flow rates based on Turnover Rate and Water Velocity and calculate the corresponding friction loss using the formula above. Plot each combination of friction loss and flow to create the system curve.

Example:

Current Flow: 70 GPM (fro mchart for existing 1 HP pump)
Current Friction Loss: 32 ft of water

Flow Rate per Turnover Requirement = 35 GPM
Friction Loss = (32 ft of Water) x (35 GPM ÷ 70 GPM)^2 = 8 ft of water

Flow Rate per Water Velocity Requirement = 63 PGM
Friction Loss = (32 ft of water) x (63 GPM ÷ 70 GPM)^2 = 26 ft of water

The point where the performance curve for a particular pump intersects the system curves determines the flow and Total Dynamic Head where that pump will operate.

5. Filter Sizing

A filter, whether it is a D.E., sand or cartridge filter, has a Design Flow Rate in GPM as well as a Turnover Capacity in Gallons. See the table below for common sizes. Choose a filter for your pool that meets or exceeds both the desired flow rate and Turnover Capacity in Gallons.

Filter Size	Effective Filtration Rate Area	Design Flow	Turnover Capacity Per 8 Hours (Gallons)	Turnover Capacity Per 10 Hours (Gallons)
18’ (Sand)	1.75 ft^2	35 GPM	16,800	21,000
21’ (Sand)	2.20 ft^2	44 GPM	21,120	26,400
22’ (Sand)	2.64 ft^2	52 GPM	24,960	31,200
24’ (Sand)	3.14 ft^2	62 GPM	29,760	37,200
27’ (Sand)	3.70 ft^2	74 GPM	35,520	44,400
30’ (Sand)	4.91 ft^2	98 GPM	47,040	58,800
36’ (Sand)	6.50 ft^2	130 GPM	62,400	78,000

Example:

Desired Flow: 50 GPM
Turnover Requirement: 21,120 gallons per 10 hours
Use a 22’ Sand Filter minimum for Desired Flow Rate and Turnover Requirements
One additional factor to consider in filter sizing is bather load. Busier pools require larger filters. Also, larger filters provide longer cycles, reducing everyday maintenance required by the consumer during the pool season.

6. Summary

Using the information in this guide, you can now properly size the pump, filter and corresponding equipment for your pool, assuring you meet Turnover Rate and Water Velocity requirements while eliminating the electrical waste and potential damage to other system components associated with a needlessly oversized pump / filter system.