Hayward Hydraulics and Pump Sizing

For Existing Pools

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Hydraulics

**Definition:** The branch of science concerned with the practical applications of fluids, primarily liquids, in motion. (2010 Britannica.com)

Hydraulics are the bloodlines of a swimming pool’s pump & filtration system – an arterial system similar to the human body’s – a mechanical, pulsating system that cleanses, recycles and reliably maintains a healthy body and flow of water.

This guide deals with the movement of water, and focuses on increasing your understanding of the following:

1. How much water do we have (pool capacity)?
2. How fast can we safely move the water (Turnover Rate and Water Velocity)?
3. How much resistance will this water meet while moving thru the system (Friction Loss)?
4. How will we overcome this resistance (Pump Sizing)?
5. How can we increase energy efficiency in regards to hydraulics and pump selection?
Hydraulic Terms & Definitions

**GPM**
Gallons Per Minute

**Turnover Rate**
The amount of time required to circulate the entire volume of water through the system. Check with local regulations for the minimum required turnover rate.

**Velocity**
The speed at which the water is flowing. Expressed in FPS or Feet Per Second. Current requirements: 6 FPS Suction side (coming from pool), 8 FPS Return side (returning to pool), per APSP-7.

**Desired Flow rate**
The flow rate between the minimum flow based on the Turnover rate and the maximum flow based on water velocity. 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 becomes loaded with dirt and debris.

**Friction Head Loss**
The resistance to water flow, as expressed in FEET OF HEAD.
System Head Loss

When all system factors are added that can contribute to the resistance of flow. Also called Total Feet of Head or Total Dynamic Head (TDH).

Atmospheric Pressure

Pressure caused by the weight of the atmosphere. Atmospheric pressure on the surface of the water is necessary for the pump to operate. At higher elevations, the pump has to produce more vacuum to pull the water up the pipe, since there is less pressure pushing on the surface of the pool water. As we go up in elevation, this pressure decreases.

Atmospheric Pressure at Sea level is 14.7 psi.
For every 1000 ft of elevation = 1.155 feet suction lift loss.

Example: A pump that can pull 10’ suction lift at sea level can only do 8.845’ suction lift at 1000’ elevation, or 4.225’ at 5000’ elevation.

Static Lift

Distance from the water level in the pool to the center of the impeller.
Cavitation

The formation of vapor bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure.

Common Symptoms of Cavitation

• A reduction in the flow of water.

• The formation of bubbles in a low pressure area of the pump volute.
  • A noise that can be heard when the pump is running.
  • Damage that can be seen on the pump impeller and volute.

Example: If you have a pump that wants to pump 80 GPM, but a 1.5" suction line that will only provide 51 GPM, cavitation may occur.
The following pages contain step-by-step instructions to answer the four questions listed on Page 1 and ultimately determine the proper size pump for virtually any existing application. Example calculations are provided below each step based on the following example:

• 16’ x 32’ rectangular pool, 3’ to 8’ deep
• 2” suction side and return side plumbing
• Existing 1 HP pump
• Filter pressure gauge reads 10 PSI (clean)
How to Determine Gallonage

**Pool Type**

**Rectangular**
Length x Width x Average Depth x 7.5 = pool capacity in gallons

**Oval**:
Length x Width x Average Depth x 6.9 = pool capacity in gallons

**Round**:
Length x Width x Average Depth x 5.9 = pool capacity in gallons

**Free Form**:
Divide the pool into the above shapes, then add together.

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**Example 1**

16’ x 32’ x 5.5’ x 7.5 = 21,120 gallons

After we know the amount of water, we can then determine what the proper turnover rate must be.
Historically, common turnover rates are 8-10 hours.

Commercial rates vary, most common is 1 turnover in 6 hours.

<table>
<thead>
<tr>
<th>Gallons</th>
<th>6 Hour Turnover</th>
<th>8 Hour Turnover</th>
<th>10 Hour Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>15,000</td>
<td>50 GPM</td>
<td>31 GPM</td>
<td>25 GPM</td>
</tr>
<tr>
<td>20,000</td>
<td>67 GPM</td>
<td>42 GPM</td>
<td>34 GPM</td>
</tr>
<tr>
<td>25,000</td>
<td>83 GPM</td>
<td>52 GPM</td>
<td>42 GPM</td>
</tr>
<tr>
<td>30,000</td>
<td>100 GPM</td>
<td>63 GPM</td>
<td>50 GPM</td>
</tr>
</tbody>
</table>

Example 2: 21,120 Gallons ÷ 8 Hours (assumed) ÷ 60 Minutes = 44 GPM Minimum Turnover Rate
Maximum GPM Flow Rates

The table below lists the maximum flow in GPM based on plumbing size and water velocity. APSP-7 Requires: 6 FPS Suction side, 8 FPS Return side maximum for residential pools.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>6 Ft/sec</th>
<th>8 Ft/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5”</td>
<td>38 GPM</td>
<td>51 GPM</td>
</tr>
<tr>
<td>2”</td>
<td>63 GPM</td>
<td>84 GPM</td>
</tr>
<tr>
<td>2.5”</td>
<td>90 GPM</td>
<td>119 GPM</td>
</tr>
<tr>
<td>3”</td>
<td>138 GPM</td>
<td>184 GPM</td>
</tr>
</tbody>
</table>

The desired flow rate must be between the minimum turnover rate and the maximum flow rate. The average of the minimum and maximum rates is the Desired Flow Rate.

**Example 3**

Minimum Flow (Turnover Rate) = 44 GPM

Maximum Flow (Water Velocity) for 2” Pipe @ 6 FPS = 63 GPM

Desired Flow Rate = 53.5 GPM
Friction Loss

Everything that the water must pass through within the circulation system – plumbing and equipment- creates resistance to flow or Friction Loss.

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 the 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 will need to add the resistance from the suction side (vacuum) of the existing pump to the resistance of the return side (pressure) of the pump. Note this assumes the Static Suction Lift is offset by the water returning to the pool.
A vacuum gauge can be used on the suction side of the system to provide a vacuum reading in inches of mercury. The pump’s drain plug port that is closest to the front of the pump is an ideal place to attach the vacuum gauge.

Take the vacuum reading of the pump and multiply the value by 1.13. This is the amount of Friction Loss for the suction side of the system.

Example 4

19 inches of mercury x 1.13 = 21.47 ft. of water.
Friction Loss – Return Side

Take the clean Filter Pressure, as measured on the filter gauge in PSI, and multiply the value by 2.31.

This is the amount of Friction Loss for the return side (pressure).

Example 5

12 PSI x 2.31 = 27.72 ft. of water.
Now that we know the amount of resistance on the suction and pressure sides of the system, we can add these values together to find the Total Dynamic Head (TDH) for the entire system.

**Vacuum feet of water + Pressure feet of water = TDH**

**Example 6**

\[ 21.47 + 27.72 = 49.19 \text{ TDH} \]

We now have all the information necessary to select the proper size pump.

**Example 7** We need a pump that will provide 53.5 GPM @ 49.19 TDH.

Note: This only determines the TDH that the pump is producing at that specific flowrate with the current state of all of the valves, etc. in the plumbing system, as well as the dirt load of the filter. This number can then be used with a performance curve to approximate the flowrate for the current system condition, but any changes in valve position or filter load would change this number.
A pump curve has three factors:
Total Feet of Head, GPM, and the actual performance curve for that pump.

Knowing any two of the three variables allows you to find the third.

SP2610X15 (1.5 HP SuperPump) is one pump for our example.
Spa Turnover Rates

Spa Jets normally require 10-15 GPM.

Check with the manufacturer for specific flow rate requirements.

The turnover rate for the pool may not be as large as the spa jet requirement.

If the spa requires more than 20% of the pool turnover rate, a two pump system should be considered.

Water Feature Rates

If the water feature(s) exceed 35 GPM, consider using a separate pump.

If less than 35 GPM is required for the water feature(s), one pump may satisfy both flow rates.

For new installations, remember to add all pipe and fittings of the water feature(s) to the TDH calculations of the pool.
By slowing down the speed of the water (velocity), the amount of resistance (TDH) in the circulation system is drastically reduced.

Reducing the TDH that the pump must overcome allows us to utilize smaller horsepower pumps and/or operate pumps at lower speeds. Below is a list of benefits associated with moving the water slower (reducing GPM flow rate).

**Note: If the flow rate (GPM) changes from the initial calculation, one must be careful to consider the change in Turnover time.**

**Benefits of Moving Water Slower**

1. Reduced TDH (lower water velocity)
2. Reduced Energy Cost (lower kWh)
3. Quiet operation
4. Less stress on the plumbing and equipment
5. Water is typically filtered to a smaller particle size.
6. Better distribution of chemicals may reduce the amount of chemicals needed.
How to Move Water Slower

1. Pump
   • Reduce the pump horsepower.
   • Reduce speed of the pump to lower the GPM flow rate.

2. System
   • Increase the plumbing size and reduce the length of plumbing required.
   • Use Fittings / elbows that account for less than resistance than others.
     Example: 45° elbows vs. 90° elbows

Energy Saving Pump Types

• Energy efficient single speed pump offering the lowest flow required.
  • 2-Speed Pumps
  • Variable Speed Pumps
How To Increase Energy Efficiency

**Lower HP, Energy Efficient Single Speed Pump Features**

- Low initial cost compared to multi-speed pumps.
- Greater efficiency verses older, higher horsepower pumps

<table>
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<tr>
<th>Capacitor Start Induction Run (CSIR)</th>
<th>40% - 55%</th>
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<tbody>
<tr>
<td>Permanent Split Capacitor (PSC)</td>
<td>45% - 60%</td>
</tr>
<tr>
<td>Capacitor Start Capacitor Run (CSCR)</td>
<td>55% - 75%</td>
</tr>
</tbody>
</table>

**Possible applications**

- Pools with 1 ½“ or 1 ¼” inch pipe
- Pools plumbed with Copper pipe
- Pools with 115 volt service only
- Very small pools with turnover rates under 8 hours.
2-Speed Pump Features

• Utilize low speed for filtering, high speed for cleaning, spa use, etc.

• Controllers can be utilized to automatically switch from high speed to low speed.

  • Excellent energy savings potential

2 Speed Pump Applications

• Customers wanting more energy savings than offered by single speed pumps.

  • Pool & Spa Combo with 2” plumbing lines.

  • Applications in areas that require multi-speed pumps by law.
Variable Speed Pump Features

- Complete control of the pump operating speed.
- Ability to tailor the pump speed to specific applications.
- Highest energy savings potential of the three pump types.

Variable Speed Pump Applications

- Applications needing three or more speeds (spas, water features, etc.)
  - New pools where pipe size can be controlled.
- Pools with small diameter plumbing that do not require higher speed settings.
  - When application calls for highest energy efficiency.
How To Increase Energy Efficiency

For existing applications

- Replace pump and other older, less efficient equipment with more new, more efficient models.
- Increase pipe size wherever possible thus reducing restriction to flow (TDH).
- Replace all 90 elbows with more efficient 45’s or short or long radius sweeps.
- Make sure the suction line to the pump is 4 to 6 times the pipe size diameter in length to help prevent cavitation. For example: If plumbing is 2”, you should have 8” – 12” of straight pipe after the last turn and before the pump.
EcoStar™ Performance Curve

SP3400VSP Performance Comparison

Flow (GPM)

Total Head (ft. Water)

- 600 RPM
- 1725 RPM
- 2400 RPM
- 3000 RPM
- 3456 RPM
TriStar ® EE Full Rate Performance Curve

[Graph showing performance curves for different models: SP3205EE, SP3220EE (Low Spd), SP3215EE, SP3220EE, SP322063EE, SP3220EE, and SP32152EE (Low Spd).]
NorthStar™ Performance Curve
TriStar® Waterfall Performance Curve
Max-Flo™ Performance Curve