

## Pump Curves

David Bankston, Food Sciences, LSU AgCenter

The best pump performance occurs when the pump is correctly matched to the application. This requires knowledge of the application and the pump. You must consider these factors to choose the correct pump:

- All water is not the same. Is the water corrosive (salty or acidic)? Is the water abrasive (does it carry sand)? If the water source is surface water, does the water contain solids such as leaves, fish, twigs or other debris? Is it recycled wastewater (pH, contain solids)? Pumps designed to handle and withstand all of these conditions may be less efficient than pumps designed for use with clean water.
- A pump's capacity to satisfy the requirements of the load is described on a graph called a pump curve.
- Cost includes the fixed cost of the equipment (pump, drive and controls), the cost of installation and operating costs such as energy, maintenance, repair and labor/management time. Fixed costs can be depreciated over a number of years at various rates. Energy costs depend on the operating schedule and efficiency of the system. Pump efficiency depends on proper pump selection, how the pump is operated and the irrigation system requirements.
- A pump may operate under different conditions after installation. For example, a pump that supplies water efficiently to multiple branches of an irrigation system

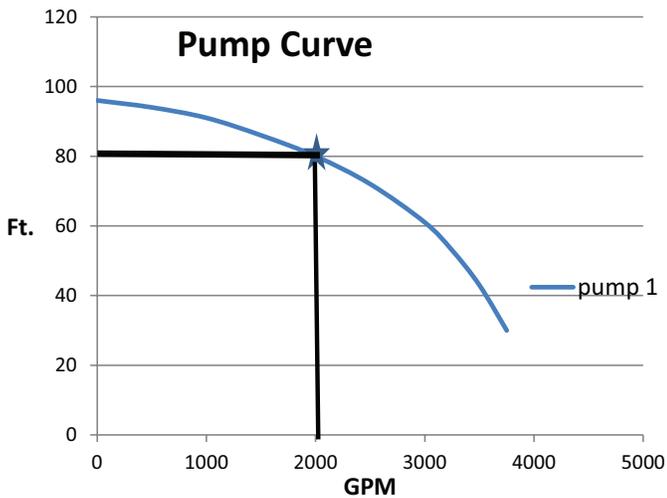
will not operate as efficiently if it is called on to supply water to just one branch of the system. Knowledge of the system characteristics and the pump curve allows prediction of the new flow rate and pressure delivered by the pump.

### The Pump Curve

The amount of water a pump delivers depends on the conditions under which it operates. For example, some pumps must be submerged, but others are capable of sucking water up to the pump. The pressure the pump needs to develop to push the water through the delivery system (pipes, hoses, elevation changes of the water, nozzles) determines the flow rate the pump will deliver.

The simplest pump curve compares head (sometimes referred to as total dynamic head or TDH in feet) or pressure (2.31 feet of head = 1 pound per square inch of pressure or psi) produced by a pump and the flow rate of water being pumped in gallons per minute or gpm. Head usually is plotted on the vertical axis of the graph and flow rate on the horizontal axis. The highest head occurs at the lowest flow rate, and the highest flow rate occurs at the lowest head.

Although these curves may be developed for the entire range of flow, from shut off to wide open, they usually show only an allowable operating range for the pump. If the pump is operated outside of this range, excessive vibration, cavitation or reduced performance may result. A typical curve may be represented as:



The curve may be read by either:

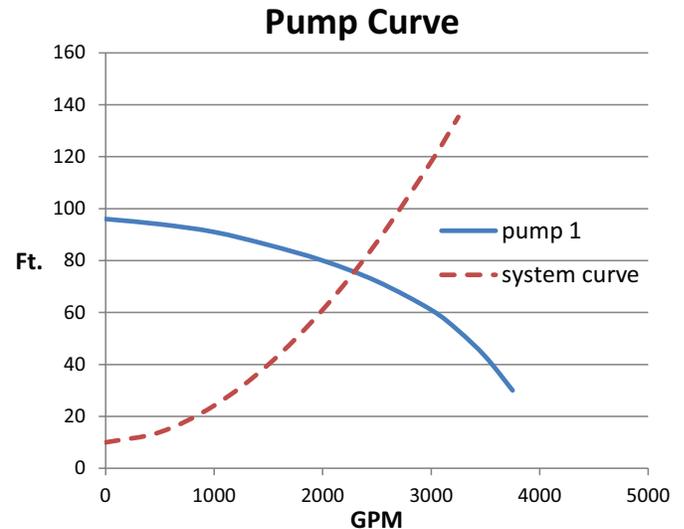
- Choosing a flow rate (for example, 2,000 gallons per minute) on the horizontal axis, proceeding vertically to the pump curve and then proceeding left to the vertical axis, thus reading the head (80 feet).
- Choosing a head (example, 80 feet), proceeding horizontally to the right to the pump curve and then vertically down to the horizontal axis, thus reading the flow rate (2,000 gpm).
- Picking a point on the curve (example, the star), proceeding horizontally to the left to the vertical axis, and reading the head (80 feet); and also from the star, proceeding vertically down to the horizontal axis and reading the flow rate (2,000 gpm).

The pump will operate somewhere on the pump curve. The “where” is determined by the system requirements.

Resistance to the flow of water on the discharge side of the pump increases as the flow rate increases. Some of the pressure developed by the pump is used to overcome this friction loss. As flow rate increases, the pressure (and energy) needed to push the water through the irrigation system increases, roughly as the square of the velocity. This is the reason pipe sizes are selected to allow operation at a low velocity. Meters, valves and elbows provide additional resistance to flow and increase pressure losses.

On the intake side of the pump, some pressure developed by the pump may be used to lift the water. This is true for pumps used in wells or in surface water. Elevations of both groundwater and surface water decline during the pumping cycle and during the irrigation season. This decline in water elevation results in a lower flow rate.

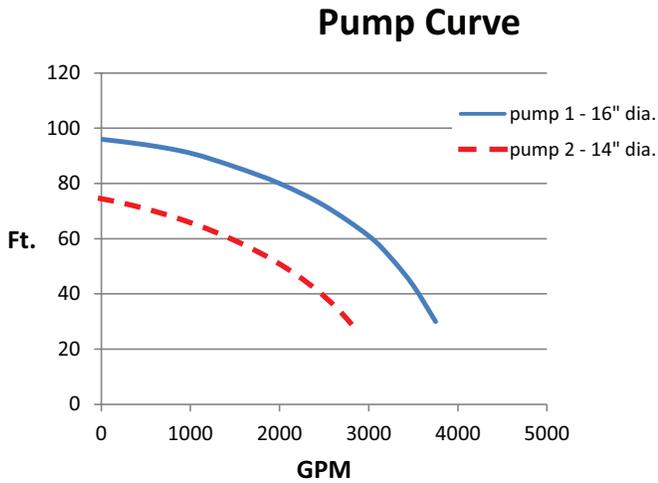
The curve obtained from adding all of the resistances to water flow is the system curve. A typical plot, including both the pump curve and the system curve, would be:



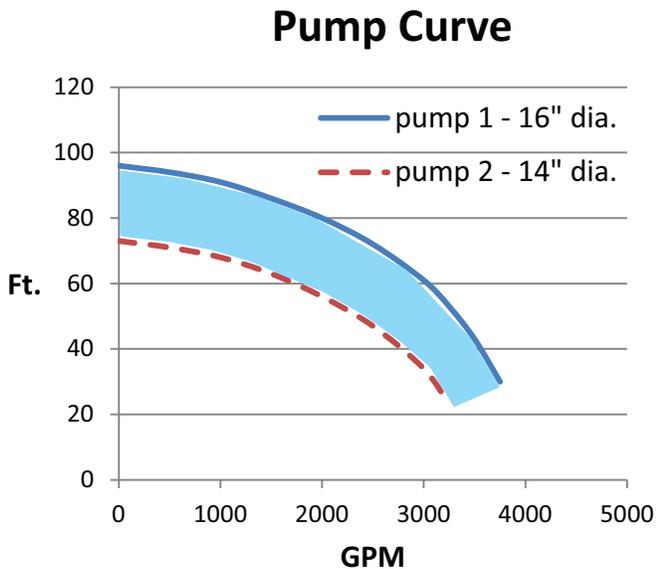
The usual procedure for picking a suitable pump is to decide what you want the pump to do (for example, lift 2,000 gallons per minute of water 10 feet and pump it through 300 feet of 12-inch diameter 80 psi PVC pipe) and then to ask your pump supplier to suggest a suitable pump. The pump supplier should be able to construct a system curve from your information and will have pump curves for the available pumps. The Southern Region Aquaculture Center has publications on the Internet under “aeration” that can assist in determining the system curve. Just remember that if the pipe diameter is too small for the desired flow, a large pressure drop will occur in the pipe.

Pump curves will specify the model of pump and operating speed (revolutions per minute). Information for different size (diameter) impellers also may be included. In some cases, a given pump casing may be able to operate with different size impellers. This allows for more choices in matching

a pump to specific needs. An example of two different size impellers is shown in the following pump curve diagram.

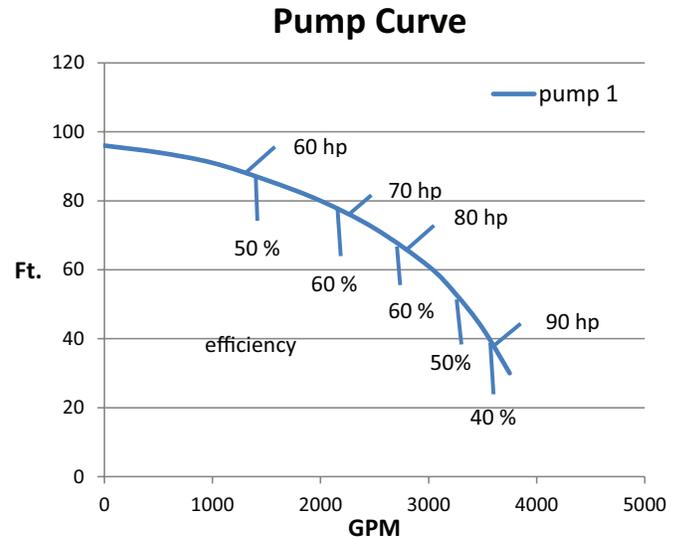


Although a pump curve may only show two impeller diameters, this does not mean you are restricted to those two diameters. An impeller with a diameter within the range of suitable impeller diameters might be acceptable. An impeller with a larger-than-desired impeller diameter might also be machined, or trimmed, to a smaller diameter and perform satisfactorily. Trimming is done by professional pump shops. Some manufacturers will represent this range of capability by showing a curve for the largest and smallest diameter impellers with a shaded area between – representing the range of performance that may be obtained by a trimmed impeller. The following diagram illustrates this concept:



Pump curves may include additional information about required horsepower input, pump efficiency and net positive suction head required, referred to as NPSHR.

The required horsepower input to a pump and the efficiency of that pump depends on where on the pump curve the pump is operating. An example of a pump curve exhibiting both horsepower required by the pump and efficiency of the pump is shown here:



Net positive suction head required involves a more detailed explanation. Low pressure on the suction side of the pump can create a vacuum and result in boiling water as it passes into the pump. The water will boil if the absolute pressure in the pump drops below the vapor pressure of the water. If the water boils, cavitation, loss of efficiency and/or damage to the pump may occur. To prevent this, a manufacturer may list, as part of operating conditions, the NPSHR for the pump. This means that the net positive suction head available must be greater than or equal to the net positive suction head required. The net positive suction head available for a pump handling water from an unpressurized source is the atmospheric pressure (in feet of water) minus the lift, head losses occurred in flow through the suction piping and the vapor pressure of the water. In equation form:

$$NPSHA = P_{atm.} - \text{Lift} - \text{head loss}_{\text{suction piping}} - \text{vapor pressure}_{\text{water}}$$

Both the atmospheric pressure and head loss vary. The vapor pressure increases with temperature. For example, at standard atmospheric pressure (14.696 psia), the vapor pressure of water is about 33 feet at a water temperature of 70 degrees Fahrenheit. But it drops to about 32.2 feet at a water temperature of 95 F. The head loss in the suction piping also can vary with age of the pipe. The lift is the distance the water must be elevated to reach the inlet of the pump when the pump is operating.

An operating pump usually results in lowering of the underground (or surface water) level near the intake for the pump. If the pump intake is below the water level (in which case the lift is negative and adds to the NPSHA), head losses in the intake piping may still result in inadequate NPSHA. Because the NPSHA can vary, a safety

Additional information about pumps and pump curves may be found at the following websites:

<https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/16/> – SRAC fact sheets about pumps

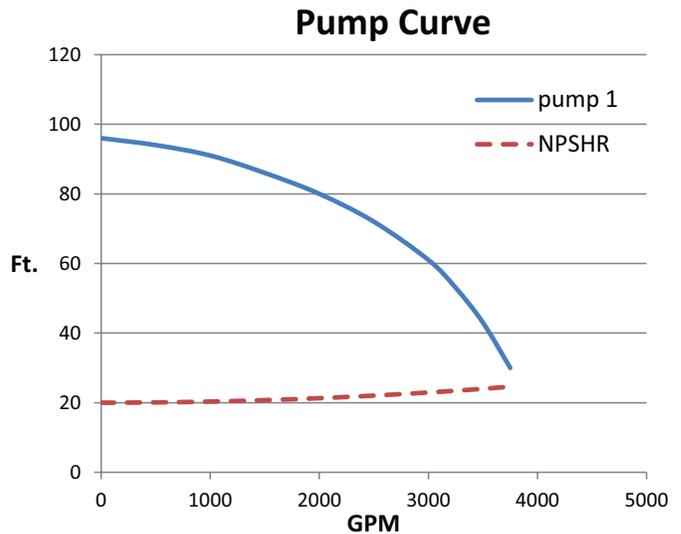
[http://www.engineeringtoolbox.com/nps-h-net-positive-suction-head-d\\_634.html](http://www.engineeringtoolbox.com/nps-h-net-positive-suction-head-d_634.html) -- Information on net positive suction head

<http://www.crisafullipumps.com/pumping-world-news/> – contains information on reading pump curves

[http://www1.eere.energy.gov/manufacturing/tech\\_deployment/pdfs/pump.pdf](http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/pump.pdf) – a 100-plus page booklet covering many aspects of pump operation, including economics

<http://www.ciras.iastate.edu/publications/EnergyBP-ChemicalIndustry/EnergyBestPractices-ChemicalIndustry-Sourcebook.pdf> – Chapter 7 covers pumps and motors

margin is used to minimize problems. The NPSHR may be shown on the pump curve with a separate vertical axis for its value for a flow rate. This is shown here:



[www.LSUAgCenter.com](http://www.LSUAgCenter.com)

Louisiana State University Agricultural Center  
Louisiana Agricultural Experiment Station  
Louisiana Cooperative Extension Service  
William B. Richardson, Chancellor and Director

Pub. 3241-H (200) 8/13

The LSU AgCenter is a statewide campus of the LSU System and provides equal opportunities in programs and employment.