

Case Study – Pump Sizing

Selecting the proper pump is the most important step in the development of a piping system. The pump must be sized to handle the desired flow rate at the required pressure from the supply to the destination. In order to size a pump, you must take into account the change in elevation and pressure from the supply source to the destination (referred to as static head). Also, losses due to friction of the fluid in the pipeline at the design flow rate must be factored into your pump selection (referred to as dynamic head). Once the static and dynamic heads are added, along with any additional head needed for proper control valve operation and safety factor, you can arrive at a pump design point for pump selection.

In addition, it is very important that there is sufficient Net Positive Suction Head available (NPSHa) at the pump suction for the pump being considered.

Pump Sizing with PIPE-FLO and Flow of Fluids

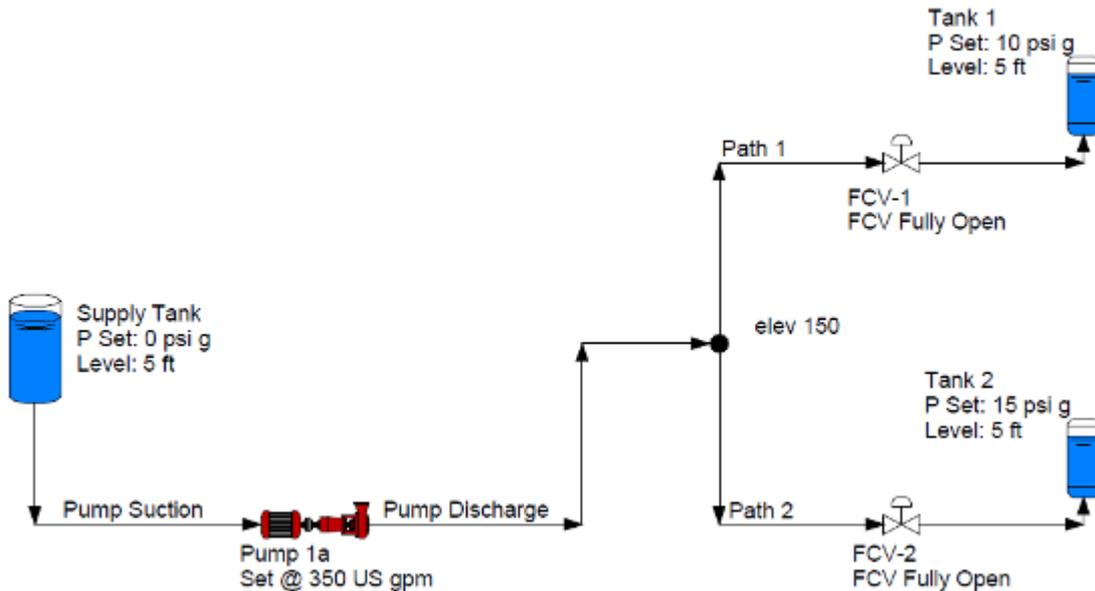
Both PIPE-FLO and Flow of Fluids programs allow you to select and size a pump directly *in* the program. In this example we will use PIPE-FLO, but the steps and calculations are the same in both programs.

The following key steps are performed when sizing a centrifugal pump:

- Calculate the Total Head (TH) for the design case condition
- Select a pump meeting the required design point
- Evaluate the pump and system together

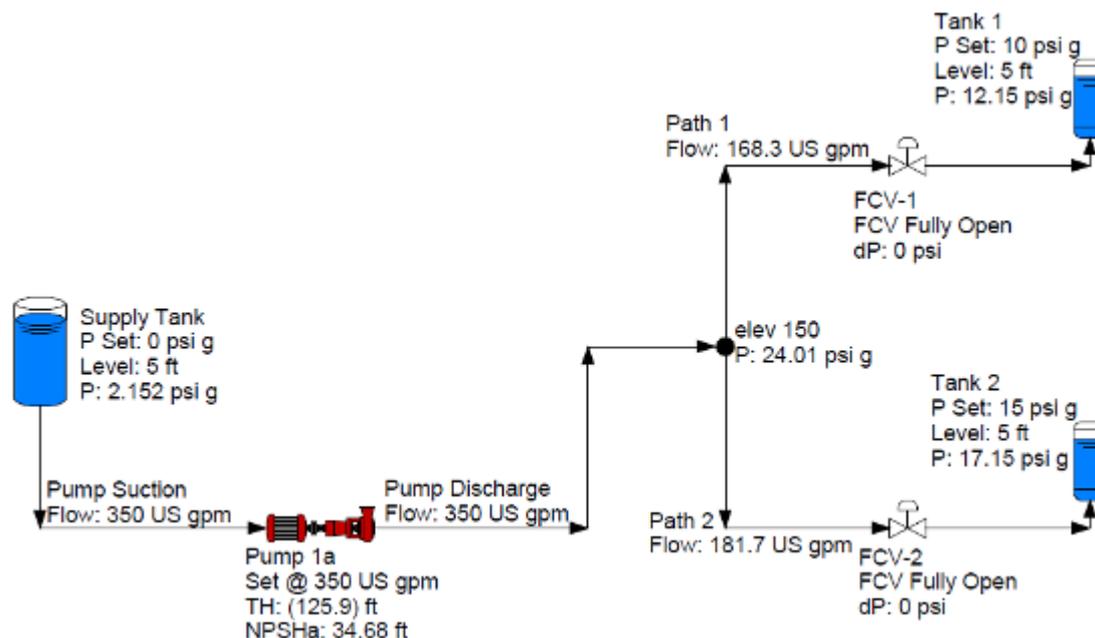
Both PIPE-FLO and Flow of Fluids automate these steps, providing a clear picture of how the pump and pipelines operate as a system.

The Piping System



The process fluid is water at 120°F, and the pump must supply water from the Supply tank at atmospheric pressure to Tank 1 with a pressure of 10 psig, and Tank 2 with a pressure of 15 psig. We want to control the flow into Tank 1 to 150 gpm and the flow into Tank 2 to 200 gpm. The fluid level in all three tanks is 5 ft.

Calculate the Total Head



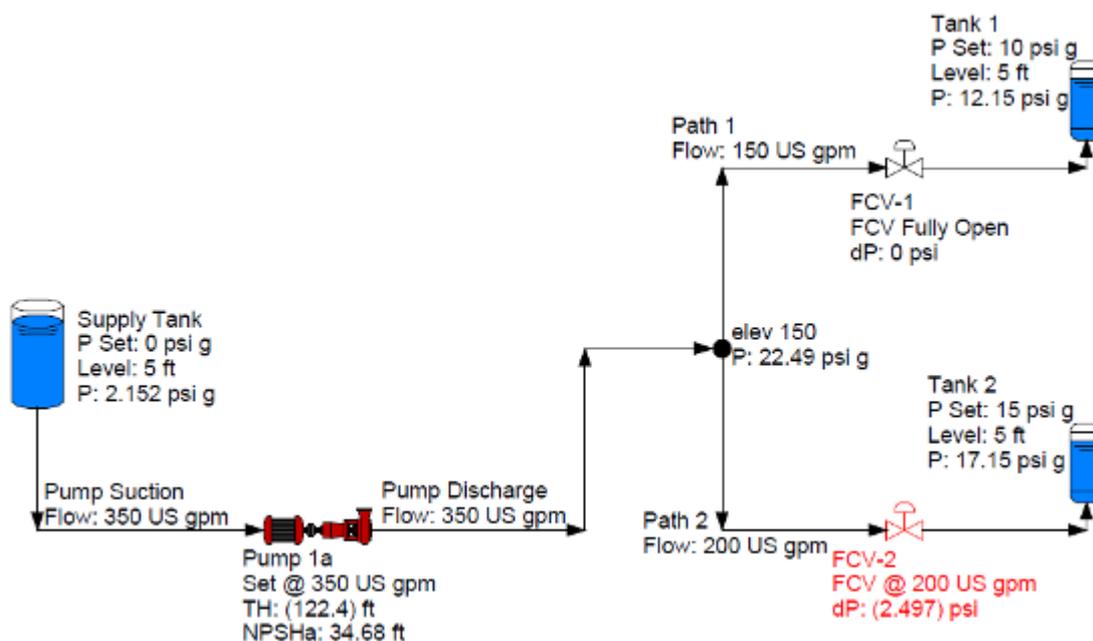
PIPE-FLO performs a full network analysis and calculates the pump's Total Head and NPSHa for the design flow rate.

PIPE-FLO calculated the Total Head at 125.9 ft needed to pass 350 gpm, but notice the flow rate in Path 1 is 168.3 gpm instead of the design requirement of 150 gpm.

Further, Path 2 has a flow rate of 181.7 gpm instead of the design requirement of 200 gpm. Notice the sum of the flow rates in paths 1 and 2 is 350 gpm, which equals the specified flow rate through the pump.

Finding the Most Hydraulically Remote Loop

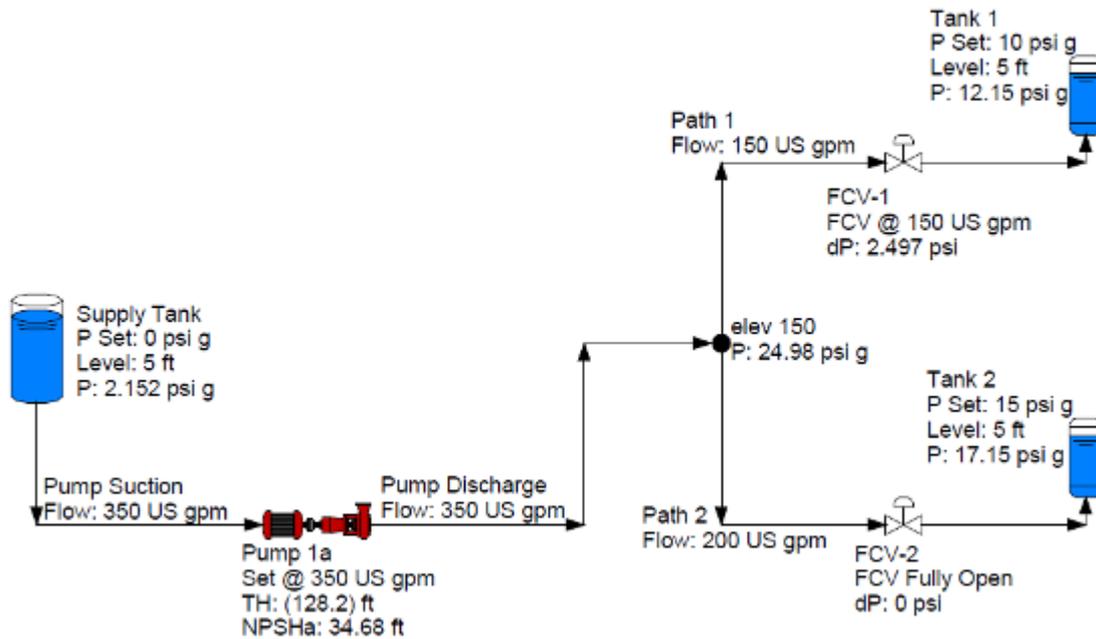
To limit the flow rate in Path 1 to 150 gpm and in Path 2 to 200 gpm, additional friction loss needs to be added to the paths. This is typically accomplished by throttling the valves in the pipelines. Both of the valves cannot be throttled though, or the flow will be defined at all points in the system, and it will be over-controlled. In order to avoid this, one of the valves needs to be left open. The valve that needs to be left open is located in the most hydraulically remote loop, or the path with the most resistance. Since we do not know which valve that is, we will throttle one of them and view the results.



You can see that by leaving FCV-1 fully open, FCV-2 turns red. The error on the valve says a flow of 200 gpm cannot be achieved. We now know we need to set FCV-1 to a set value, and set FCV-2 to fully open.

(In a system with many control valves, the easiest way to find the most hydraulically remote loop, is to set one valve to fully opened, then view the results in the list window. The valve with the most negative dP is the most hydraulically remote, and needs to be set to fully open.)

Let's set FCV-2 to fully open.



The increased differential pressure across the FCV-1 reduces the flow rate through the path. This also increases the pressure at the pipe junction named elev 150. This, in turn increases the differential pressure from the junction at elev 150 ft to Tank 2, and thus increases the flow rate in Path 2.

The pressure continues to increase back to the pump discharge. PIPE-FLO calculates the differential pressure required across the Flow Control Valve in Path 1 to limit the flow rate to 150 gpm. Notice the pump's Total Head increased to 128.2 ft as a result of the throttled valve in the pipeline going to Tank 1.

Selecting the Pump

PIPE-FLO calculated the Total Head and NPSHa for the design flow rate, but no additional head was added for proper valve operation needed in Path 2 or for a system uncertainty factor. To insure at least a 10-psi drop across the controlling valve in Path 2, and to factor in uncertainties in the way the system is actually built, a design point of 350 gpm at 160 ft Total Head will be used in pump selection.

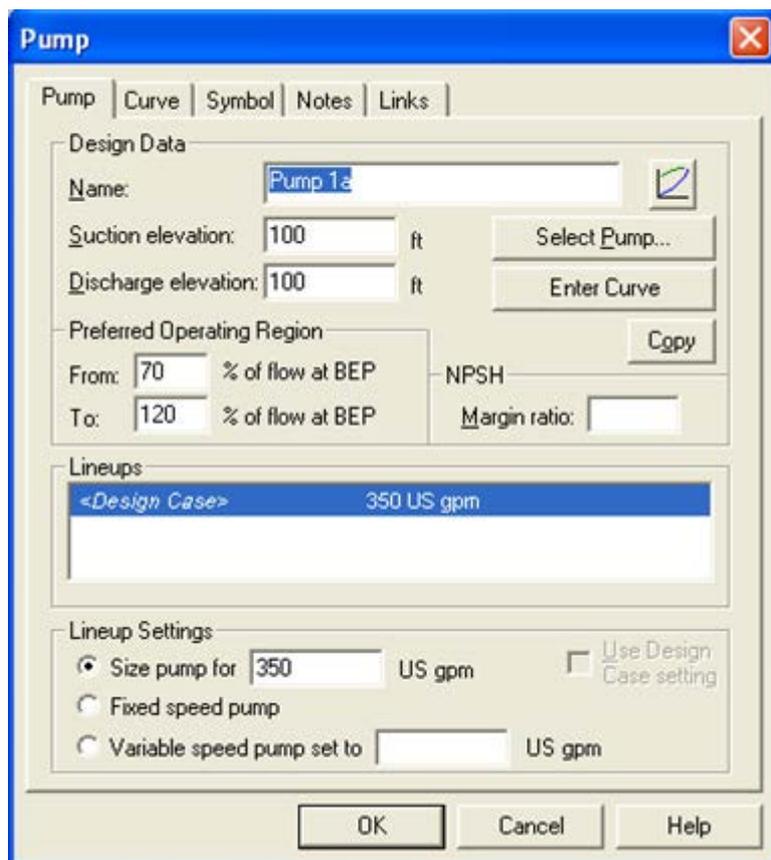
When selecting a pump the following steps are performed:

- Determine the design point for pump selection
- Choose a pump manufacturer
- From the manufacturer's catalog select the desired pump type(s) and synchronous speed(s)

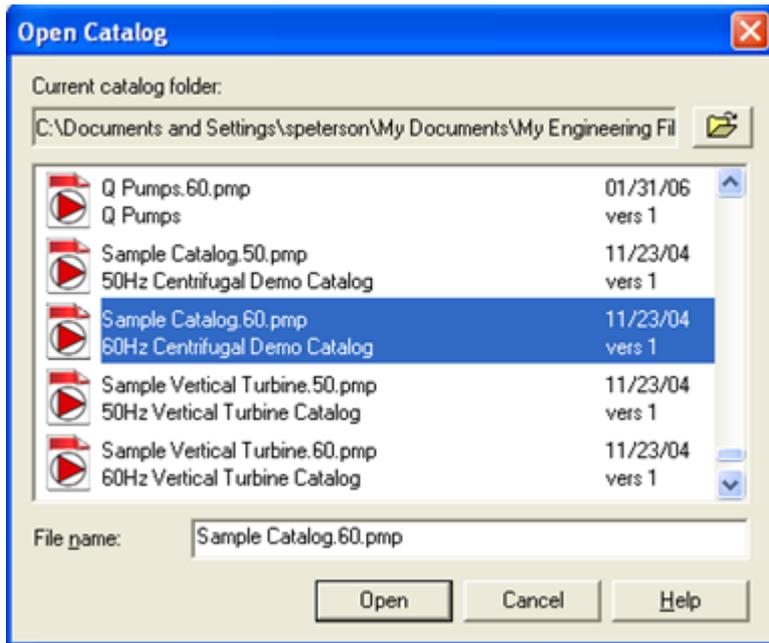
- Look through the pump curves and add the pumps that meet the design point to the list for additional evaluation
- Calculate the impeller diameter needed to meet the design point
- Evaluate each pump and choose the best one for the system

Selecting a pump using the PIPE-FLO program

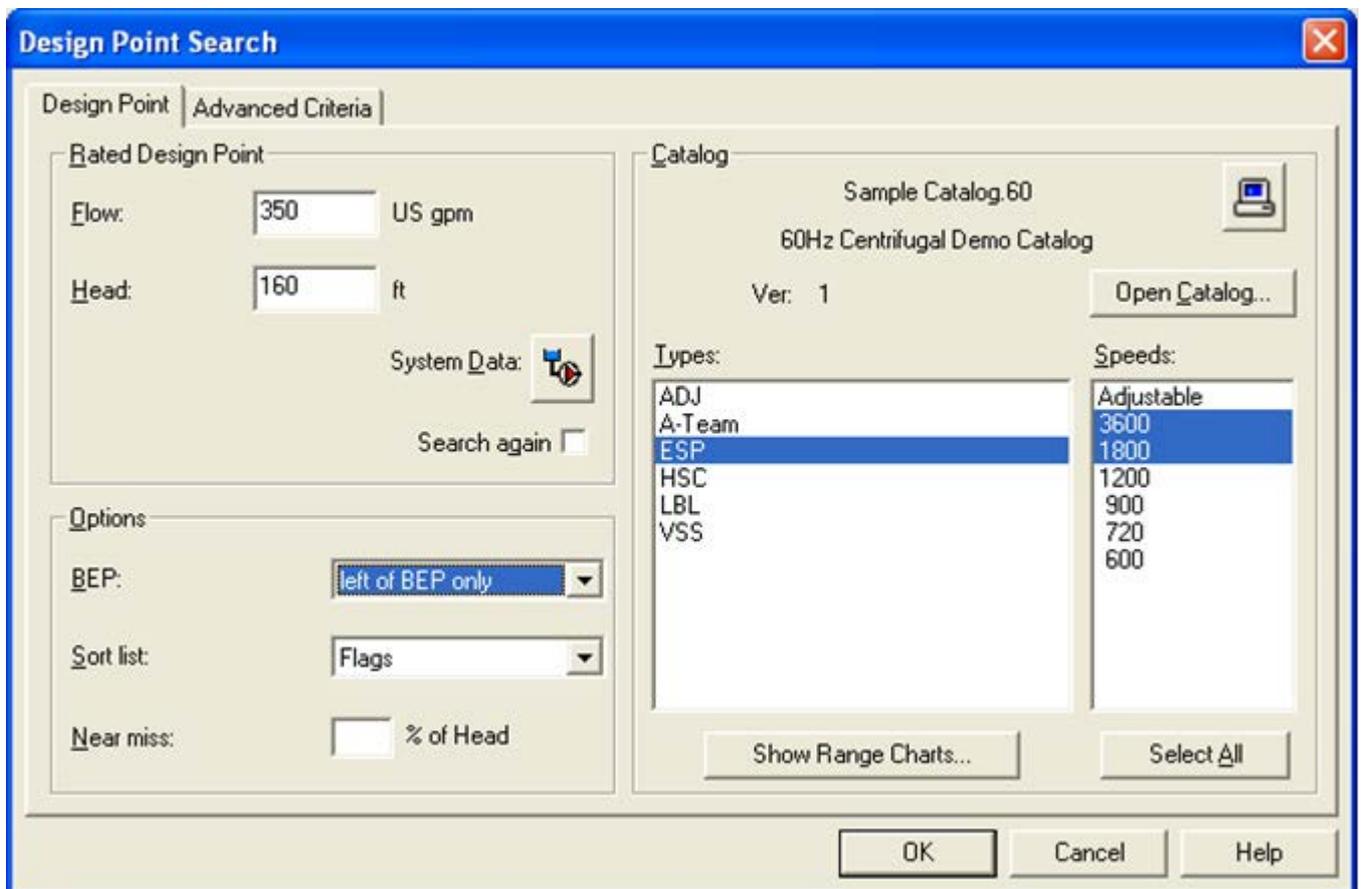
In the pump dialog box, we will need to click Select Pump



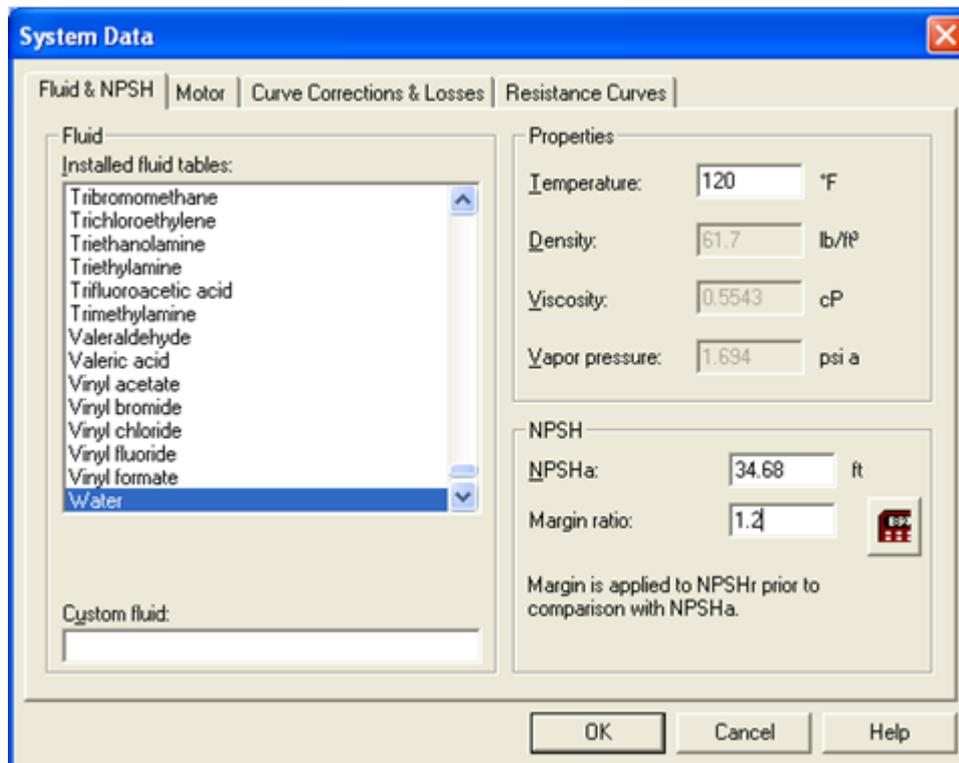
From there we will select a pump manufacturer's catalog. In this case, we will select Sample Catalog 60.



In the Design Point tab in the Design Point Search dialog box, we will need to specify the flow and head in the Rated Design Point box. Then we will specify the type of pumps and speeds to search within. We can also specify the operating point in relation to the best efficiency point (BEP) in the Options box.



If we click on the System Data button, , it opens the System Data dialog box. Here we are able to specify a NPSH margin ratio.



In the Advanced Criteria tab, in the Design Point Search dialog box, we can enter a Preferred Operating Region.

Design Point Search

Design Point | Advanced Criteria

Preferred Operating Region

From: % of flow at BEP

To: % of flow at BEP

Pump Limits

Max temperature: °F

Max suction pressure: psi g

Max sphere size: in

Max power: hp

Max suction specific speed: (Nss)

Secondary Operating Point

Flow: US gpm

Head: ft

Curve Limits

Minimum trim: % of max diameter

Min head rise: % to shutoff

The pump selection list displays the pumps in the selected catalog meeting the pumping requirements of pump type (ESP), pump speed (3600 or 1800 rpm) and design point of 350 gpm and 160 ft Total Head, with the design point to the left of the pump's Best Efficiency Point.

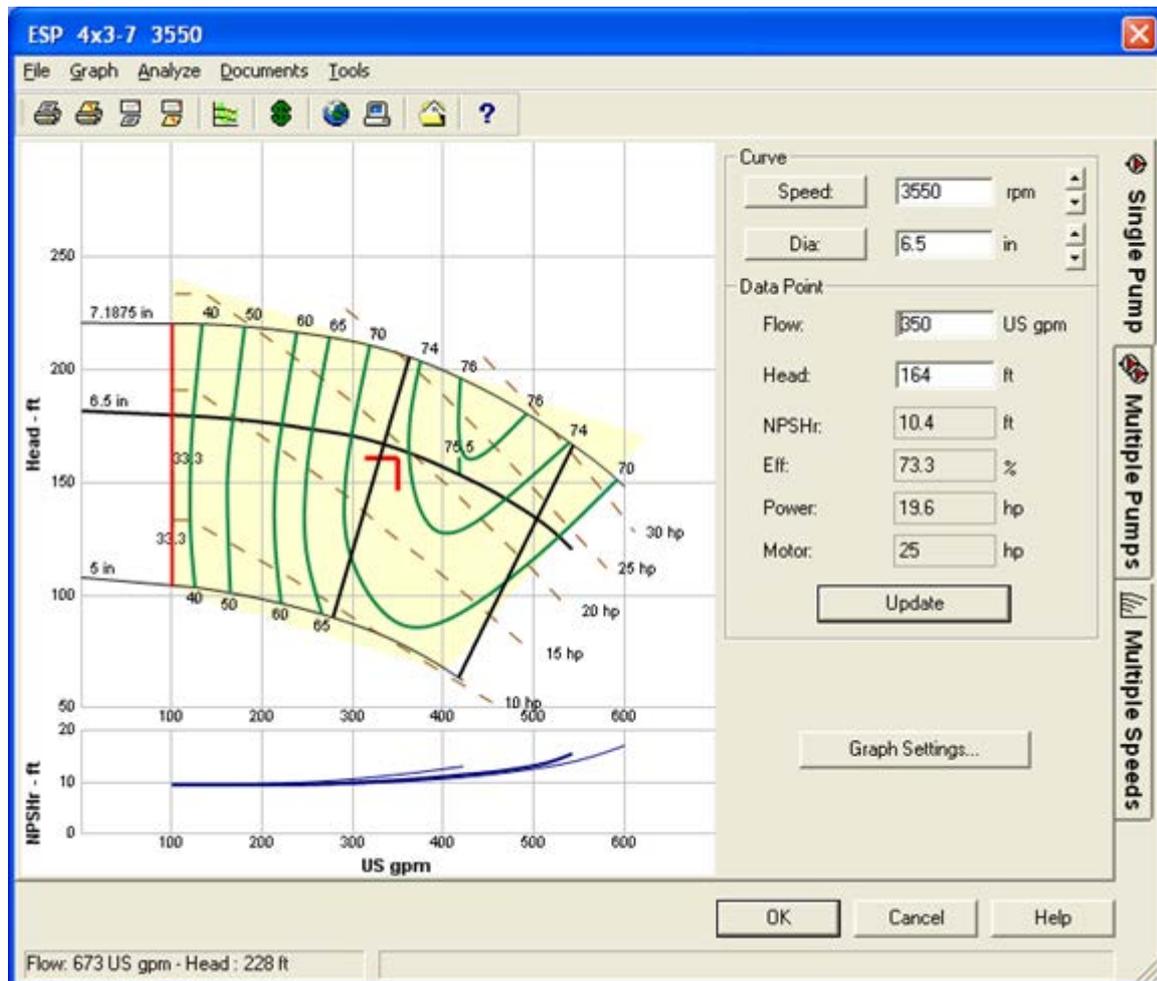
Pump 1a - Pump Selection

Graph Preview	Flags	Type	Size	Speed	Dia	Head	Eff	BEP	NPSHr	Pwr	Motor	Energy	Energy VFD	Min Flow
	---	ESP	4x3-7	3550	6.5	164	73.3	75.5	10.4	19.6	25	---	---	100
	---	ESP	4x3-8B	3500	6.75	161	64.8	66.3	11.5	21.7	30	---	---	130
	1	ESP	4x3-10	3560	6.75	163	63	65.5	11.2	22.4	30	---	---	150
	1	ESP	4x3-13	1780	11.875	161	63	73.1	4.79	22.3	40	---	---	168

4 pumps selected from 60Hz Centrifugal Demo Catalog [Design Point: 350 US gpm, 160 ft] [NPSHa: 34.68 ft, margin ratio: 1.2]

Viewing the Pump Curve

Now we will look at the pump curve for the 4x3-7 ESP 3550 pump. After reviewing the pump curve, if it is the pump we want to select, it can be inserted into the piping system model.



NOTE: The 4x3-13 and 4x3-10 pumps are red and appear at the bottom of the list. That is because they do not meet one or more of the advanced search criteria. In both cases the design point does not fall within the specified Preferred Operating Region.

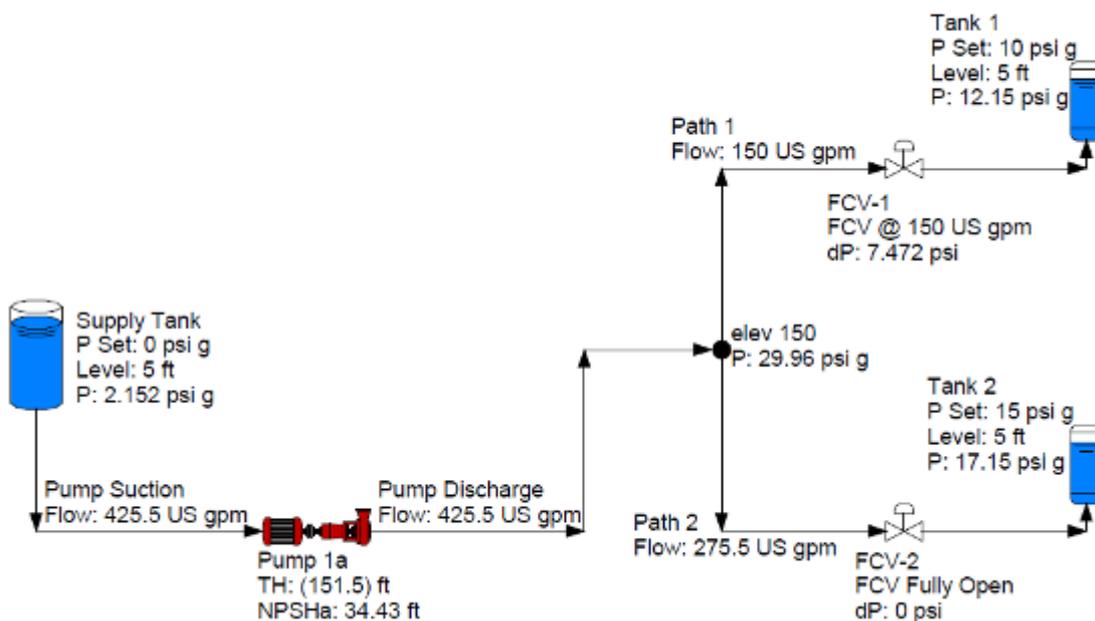
Once we decide on a pump, we will transfer the pump data to the system.

The key to pump selection is the Electronic Pump Catalogs. The creation of a pump catalog is a joint effort between Engineered Software and the pump manufacturer. We supply the program and they supply you with their pump operating data in a form that can be read by PIPE-FLO.

The pump catalogs come from the manufacturers. The current list of [available electronic pump catalogs](#), along with contact information can be found on Engineered Software's Website. Many of the manufacturers have pump catalogs available for immediate download from [this website](#) while others may require you to contact them for these catalogs.

Evaluating a Pump in the System

Once the pump is selected, the system can be calculated with the pump running on its performance curve data.

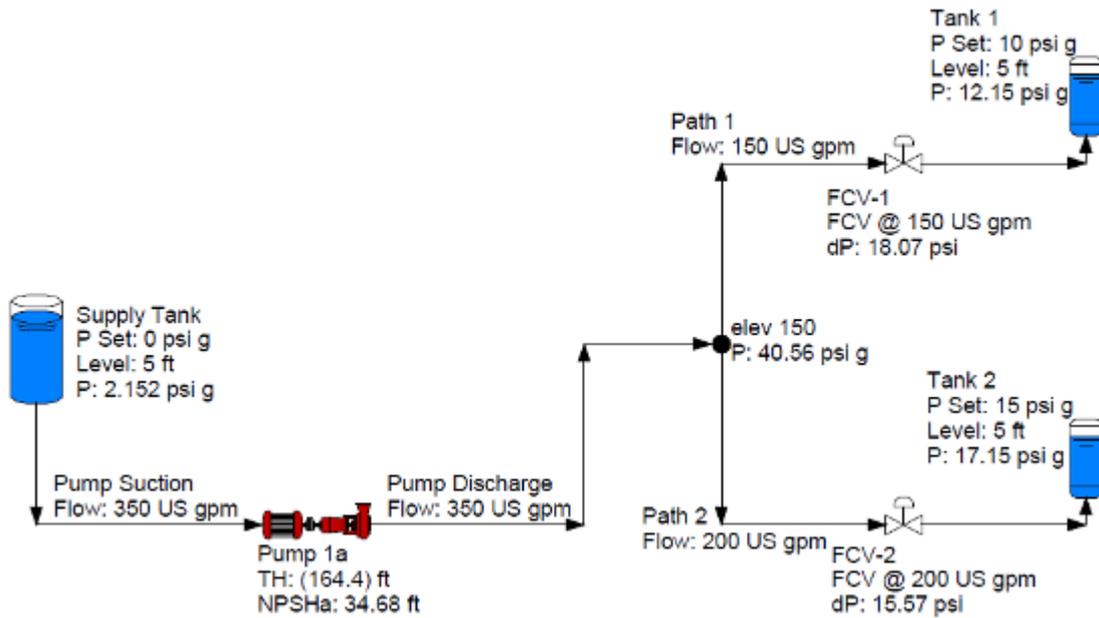


PIPE-FLO performs a full network analysis and calculates the balanced flow rate through the piping system as well as the pump's total head.

In reviewing the calculations, notice that Path 1 is limited to 150 gpm because of the control valve in the system. The control needs to have a differential pressure of 7.472 psi to limit the flow rate to the set value.

Notice the pump is delivering 425.5 gpm even though it was sized for 350 gpm. The reason for the difference is the additional Total Head that was added to the design point when selecting the pump. This additional head was needed for the control valve, as well as for a safety factor.

Now let's see how the system operates under normal conditions, with both control valves at set values.



The differential pressures for FCV-1 and FCV-2 increase to limit the flow rate through the valves to the set point. With the pump installed in the system we can evaluate how this system operates under any operating condition. This information can be used to select and evaluate the control valves.