Case Study - Time Simulation with PIPE-FLO

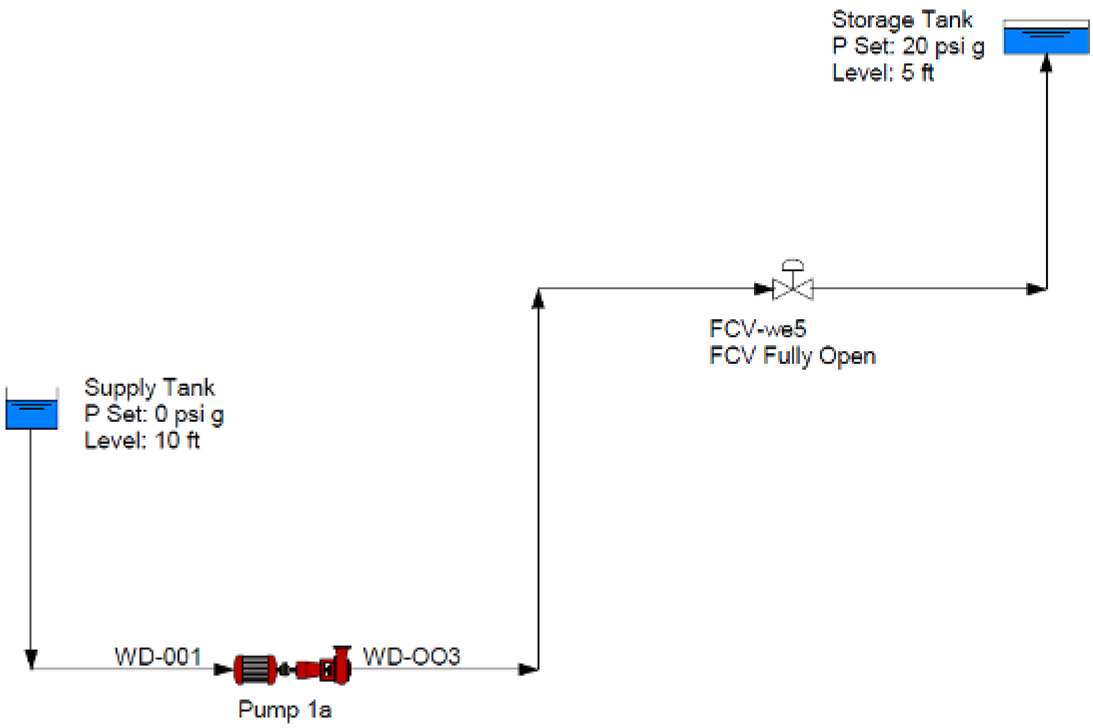
It is often necessary to see how a piping system operates over time. For example, as a tank is pumped down, the static head increases resulting in a smaller flow rate through the pump. This reduction in flow rate causes the tank to take longer to pump down. This type of calculation is called an extended period simulation. PIPE-FLO is a steady state hydraulic analysis program, and therefore is not designed to perform extended period simulation. However, there are a couple of options for extending PIPE-FLO's capabilities to include dynamic system analysis. In PIPE-FLO, you can use the Lineup feature, and some simple calculations outside the program to perform some simple time simulation studies.

If you have Engineered Software's Overtime program, you can simulate any PIPE-FLO system's operation over an extended period of time. The Overtime program gives the user complete control over the duration and frequency of a time simulation. In addition, it allows for a dynamic analysis of even the most complex PIPE-FLO systems. For those customers who have the Overtime program, please refer to the Case Study titled Time Simulation with Overtime.

When performing a time simulation of a piping system operation in PIPE-FLO, you must take into account how the boundary conditions change over time. For example if a pump is pumping one tank down, and filling another tank, the changing tank levels have an effect on the flow rate through the pump. The changing tank levels are the boundary conditions for the system.

Since PIPE-FLO is a steady state program, it calculates how the piping system operates at an instant with a fixed set of boundary conditions. By performing multiple steady state calculations for different boundary conditions with PIPE-FLO, and using a spreadsheet you can perform a time simulation of your system.

Piping System



Let's say you want to see how long it will take Pump 1a to lower the tank level in the Supply Tank from 10 ft to 5 ft. This is a time simulation type of problem. As the Supply Tank is pumped down the Storage Tank is filled. This change in elevation of both the Supply and Storage tanks causes the static head to increase. This increase in static head causes the pump to run back on its curve resulting in a reduced flow rate through the pump as the Supply Tank is pumped down.

The capacity for the Supply Tank is 10,000 gallons with 10 ft of working level, resulting in 1,000 gallons per ft of tank level. The Storage tank has a capacity of 20,000 gallons with a working level of 10 ft, resulting in 2,000 gallons per ft of tank level.

The starting condition for the Supply tank is 10 ft of level, and 5 ft of level in the Storage tank. The pressure is controlled in the Storage tank to a constant 20 psig regardless of tank level.

Setting the Lineups

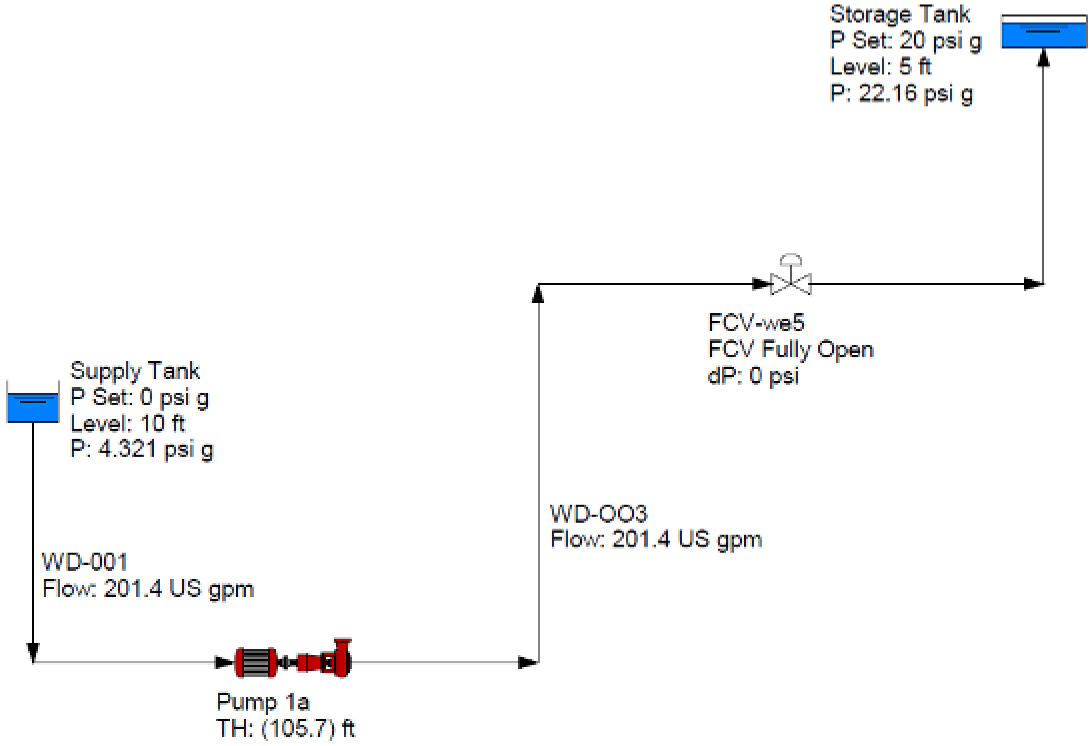
Next we will set the lineup conditions we want to calculate for. Since we want to know how long it will take to pump the Supply tank down to 5 feet, we will have our lineups set to various levels in the Supply and Storage tanks. We will create a separate lineup for each foot of level change in the Supply tank. This will require 5 separate lineups: one for each level slice.

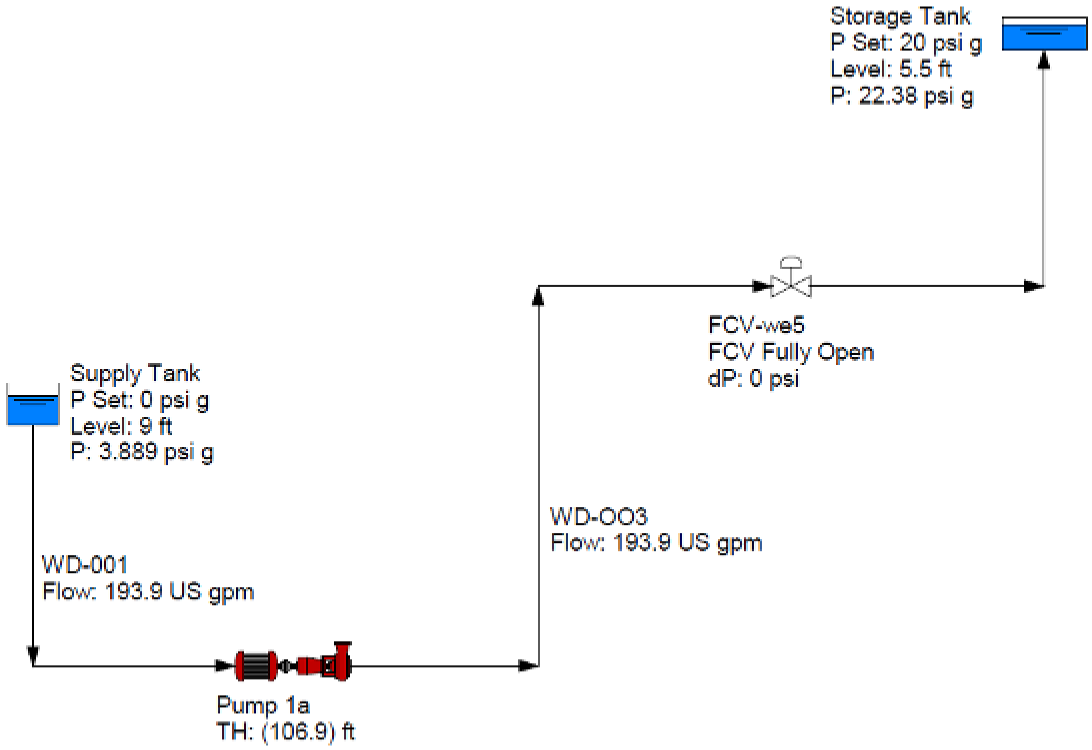
Lineup Name	Supply Tank Level	Storage Tank Level

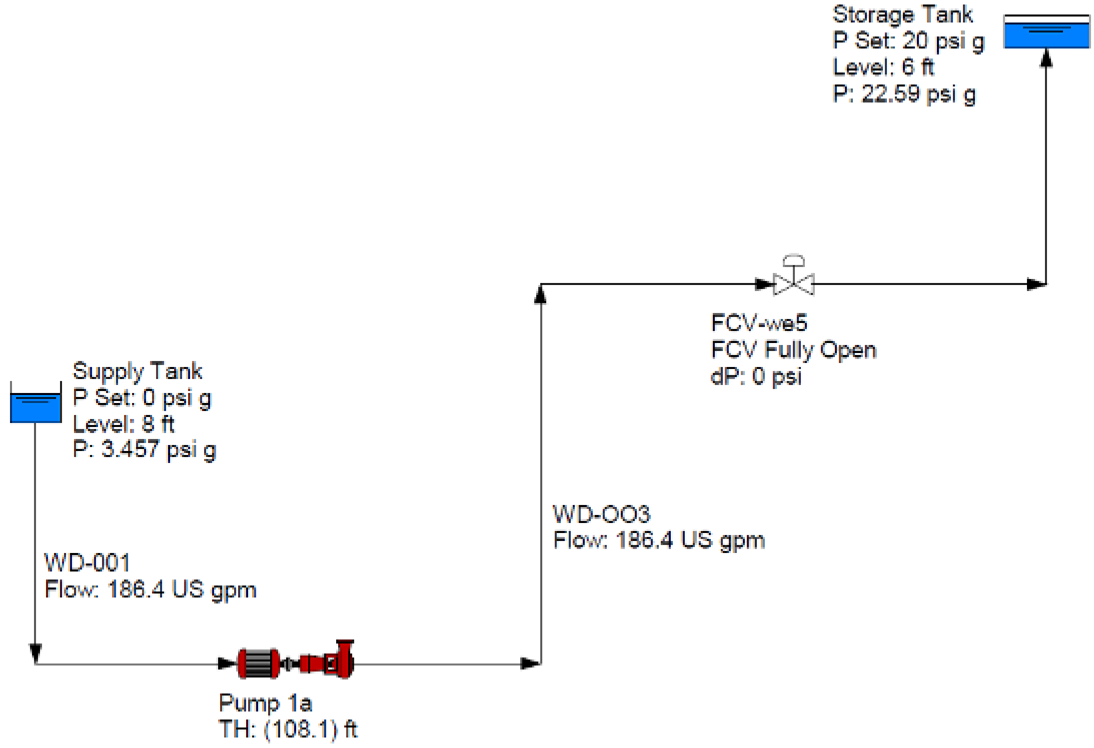
Design Case	10	5
Supply Tank 9 ft	9	5.5
Supply Tank 8 ft	8	6
Supply Tank 7 ft	7	6.5
Supply Tank 6 ft	6	7

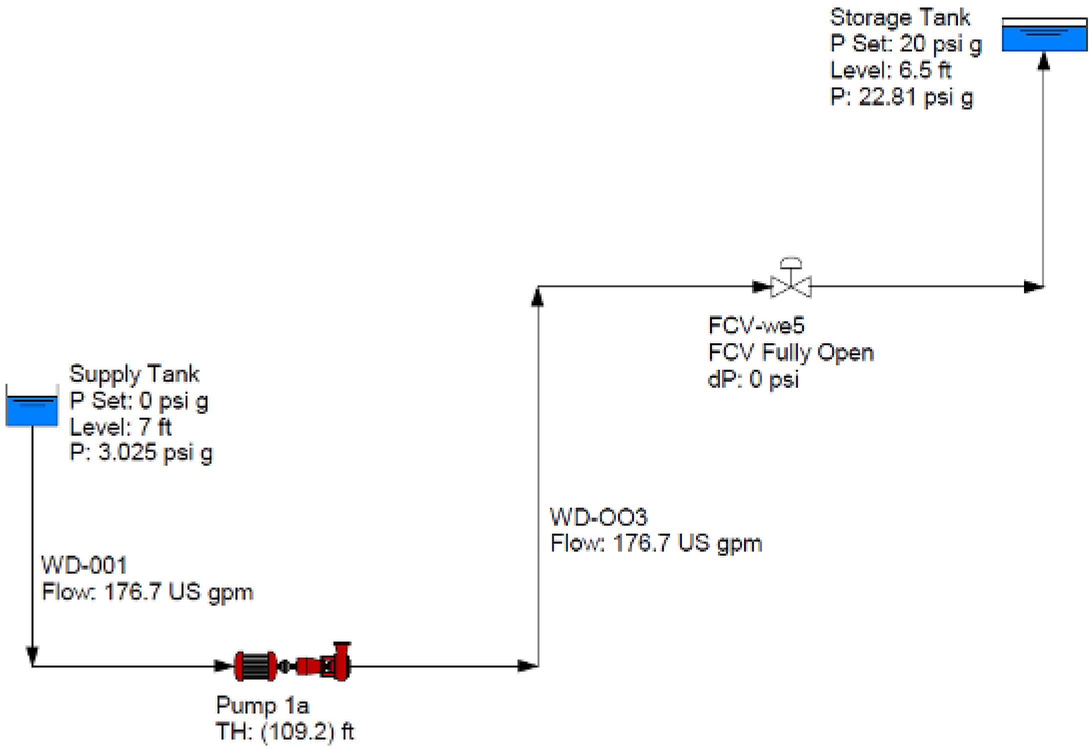
Calculating the Flow Rates

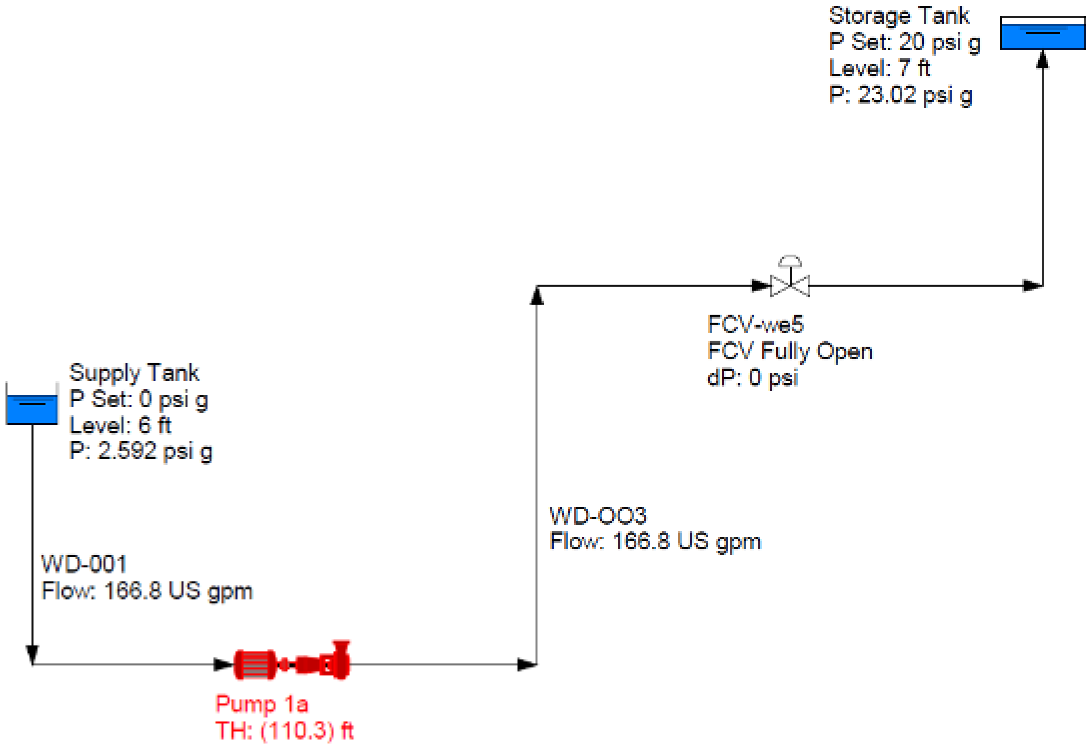
Next we will calculate the flow rate through Pump 1a for each of the lineups. We know that in order to drop the level in the Supply Tank by 1 ft, we must pump out 1000 gallons. Therefore, we will take 1000 gallons, and divide by each of the lineups' flow rates to come up with the data in the following table. When we add up the times in the last column, we find the total time to drain the Supply Tank down to 5 ft.




Storage Tank
P Set: 20 psi g
Level: 5.5 ft
P: 22.38 psi g
FCV-we5
FCV Fully Open
dP: 0 psi
Supply Tank
P Set: 0 psi g
Level: 9 ft
P: 3.889 psi g
WD-OO3
Flow: 193.9 US gpm
WD-001
Flow: 193.9 US gpm
Pump 1a
TH: (106.9) ft


Storage Tank
P Set: 20 psi g
Level: 6 ft
P: 22.59 psi g
FCV-we5
FCV Fully Open
dP: 0 psi
Supply Tank
P Set: 0 psi g
Level: 8 ft
P: 3.457 psi g
WD-OO3
Flow: 186.4 US gpm
WD-001
Flow: 186.4 US gpm
Pump 1a
TH: (108.1) ft





Lineup Name	**Flow rate in Pump 1a (gpm)**	**Time to drain 1 ft level** (1000 gal / gpm) = (min)
Design Case	201.4	4.97
Supply Tank 9 ft	193.9	5.16

Supply Tank 8 ft	186.4	5.36
Supply Tank 7 ft	176.7	5.66
Supply Tank 6 ft	166.8	6.00
Total time:		**27.15**

Notice the flow rate through pump 1a gets smaller as the Supply Tank level decreases and the Storage Tank level increases. Using this method, we determine the total pump down time to be 27.15 minutes.

Final Note

The accuracy of the pump down time depends on the number of level slices we take. As we increase the number of level slices, the figure becomes more accurate. For example if we had only used the design case flow rate of 201.4 gpm, we would have calculated 24.83 minutes to pump down the tank. When using 5 level slices we calculated 27.15 minutes. If we were to use 10 level slices the time to pump down the tank increases to 27.53 minutes. As the number of level slices increase we will be getting closer to the actual time it takes to pump down the tank to a level of 5 feet. By using PIPE-FLO and simple external calculations, you can perform some simple time simulations.

If, on the other hand, your piping system is more complex in design, and you wish to have more control over the duration and frequency of the calculations, then the Overtime program can provide you with all the necessary tools. With Overtime, you can program all of the conditions and effects which dictate the operation of your piping system. In addition to that, you can graph the results and get a very clear picture of how your system currently operates, and even get a picture of how your system would operate if you were to change the conditions. Please refer to the Case Study Time Simulation with Overtime.