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Add a Fixed dp Component to the Most Hydraulically Remote Loop

In the process of sizing a pump in PIPE-FLO, an over-controlled error may be encountered. Typically, this occurs when your pump is set to the "Size pump for" lineup setting and your flow rates are defined at all points in the system.

In Figure 1 below, the supply pump is being sized for 800 gpm to provide 400 gpm to each Product Tank. If the control valve to each tank is set to 400 gpm, using the "Automatic set value" setting, and the pump is set to 800 gpm while using the "Size pump for" setting, an over-controlled error message will be displayed when the model is calculated.
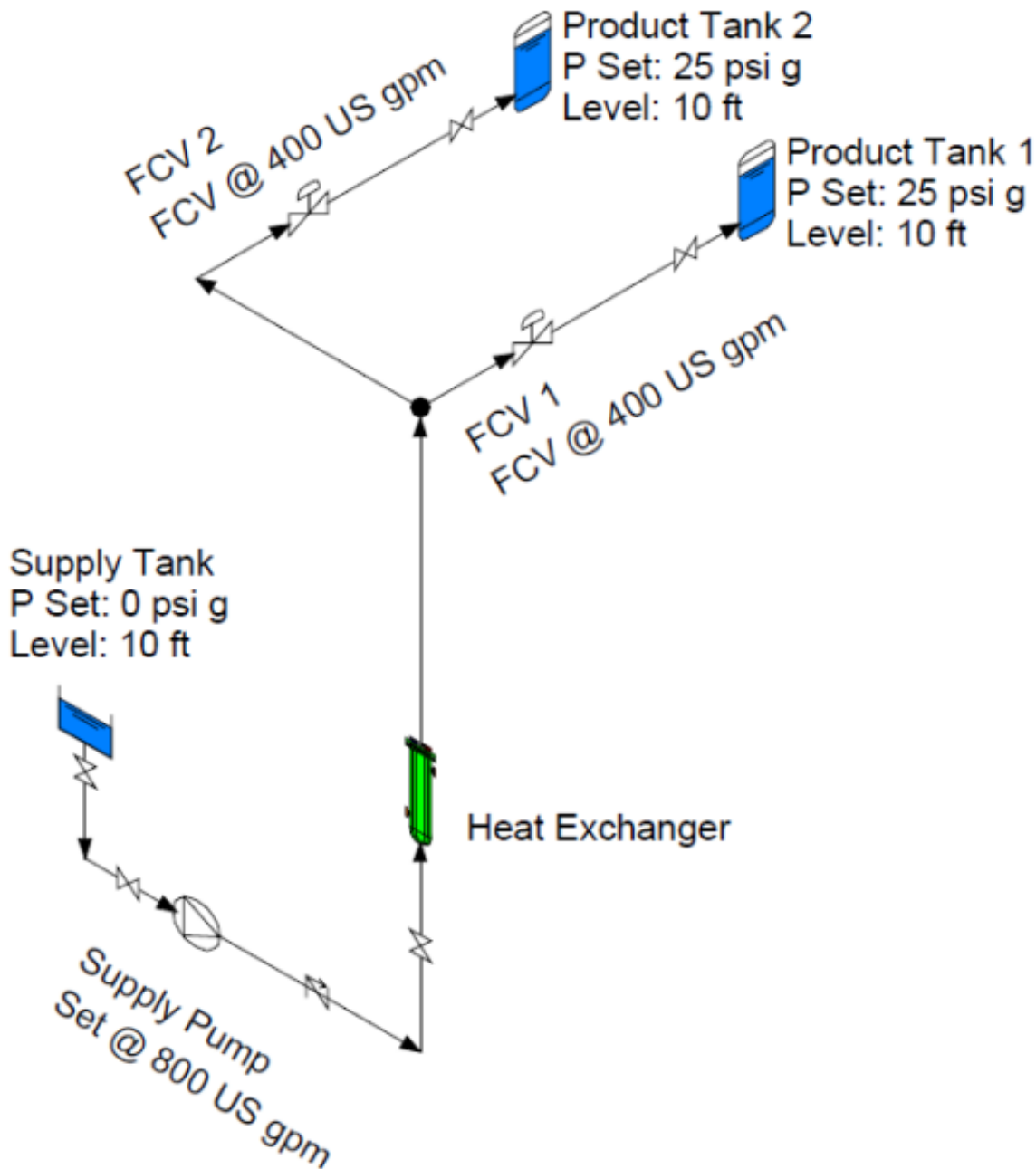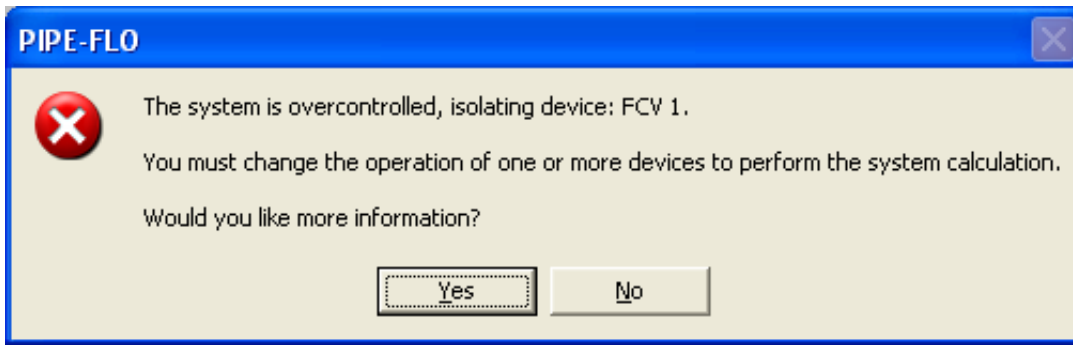
Figure 1. Over-controlled Error resulting from defining system flow rate at the pump and at both control valves.

To resolve this error message, one of the control valves should be set to *"Fully open"* and the other set to 400 gpm. This will ensure that each tank will get 400 gpm. But which valve should you choose to set to fully open?

This is where the Most Hydraulically Remote Loop (MHRL) comes into play. This is the loop or branch that is "hydraulically" the farthest from the pressure source (pump). This may not be the loop that is *physically* the farthest from the source because other factors such as elevation changes and pipe sizes may make a loop farther from the source "hydraulically". The MHRL is essentially the loop that is the most resistive to fluid flow in the system.

The control valve in the MHRL is the one that needs to be set to "Fully open." To find the MHRL, set any of the control valves in the model to "Fully open" and calculate the model. If the set point of one or more control valves cannot be achieved (see Figure 2), the valve with the highest negative pressure drop (i.e. a pressure gain) will be in the MHRL. If there are a lot of valves in your model with a negative pressure drop, you can find the MHRL quickly be pulling up the list view for controls and sorting the list from lowest to highest dP.
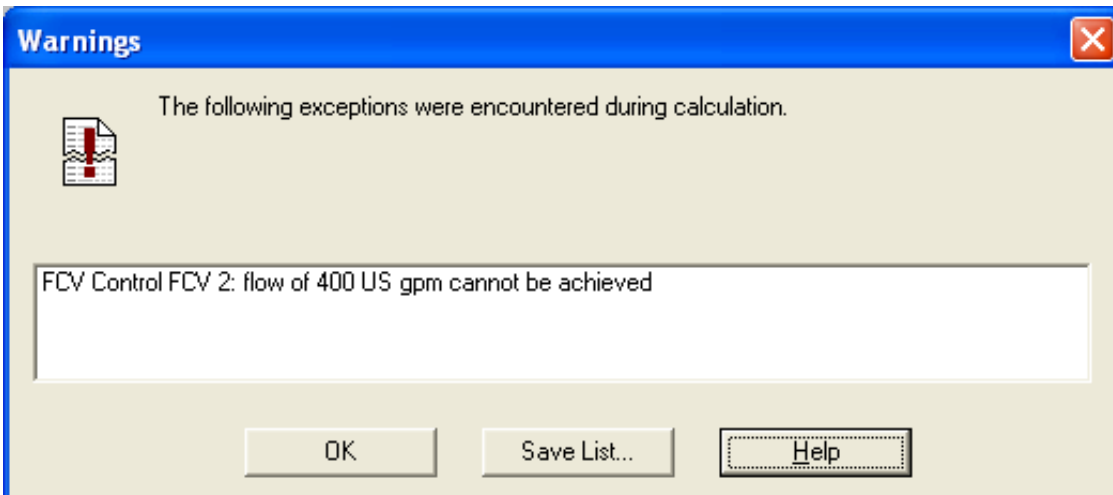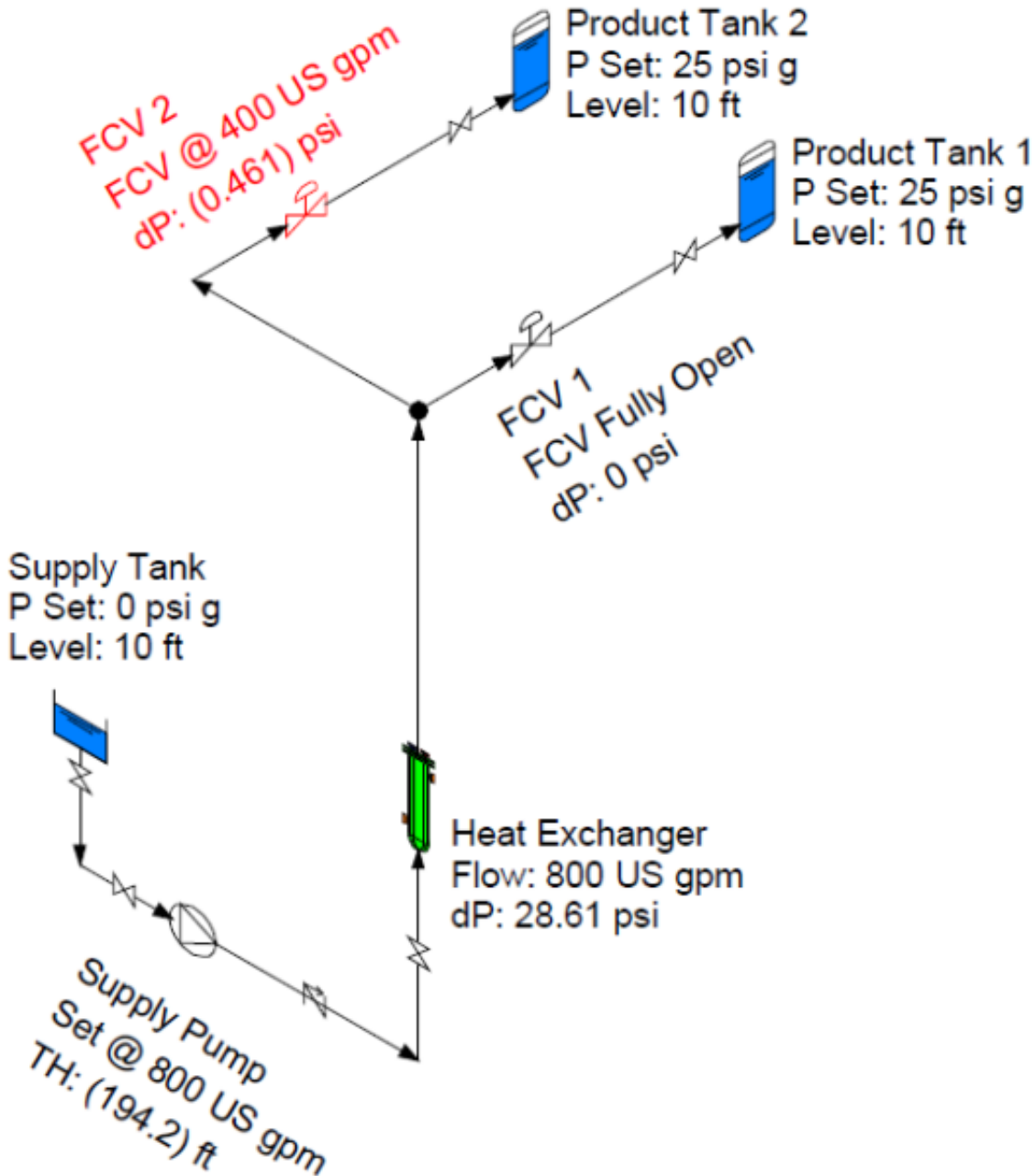
Product Tank 2
P Set: 25 psi g
Level: 10 ft

FCV 2
FCV @ 400 US gpm
dP: (0.461) psi

Product Tank 1
P Set: 25 psi g
Level: 10 ft

FCV 1
FCV Fully Open
dP: 0 psi

Supply Tank
P Set: 0 psi g
Level: 10 ft

Heat Exchanger
Flow: 800 US gpm
dP: 28.61 psi

Supply Pump
Set @ 800 US gpm
TH: (194.2) ft

Warnings

The following exceptions were encountered during calculation.

FCV Control FCV 2: flow of 400 US gpm cannot be achieved

OK   Save List...   Help

Figure 2. Flow cannot be achieved in most hydraulically remote loop.

Set the flow rate back to the desired value in the control valve you just set to fully open, and then set the control valve you identified with the highest negative pressure drop to "Fully open."

With the MHRL control valve identified and set to "Fully open," the model will calculate as shown in Figure 3. Notice the dP across FCV 2 is shown as 0 psi and the dP across FCV 1 is 0.461 psi. Also, notice the pump's Total Head is 195.3 ft.
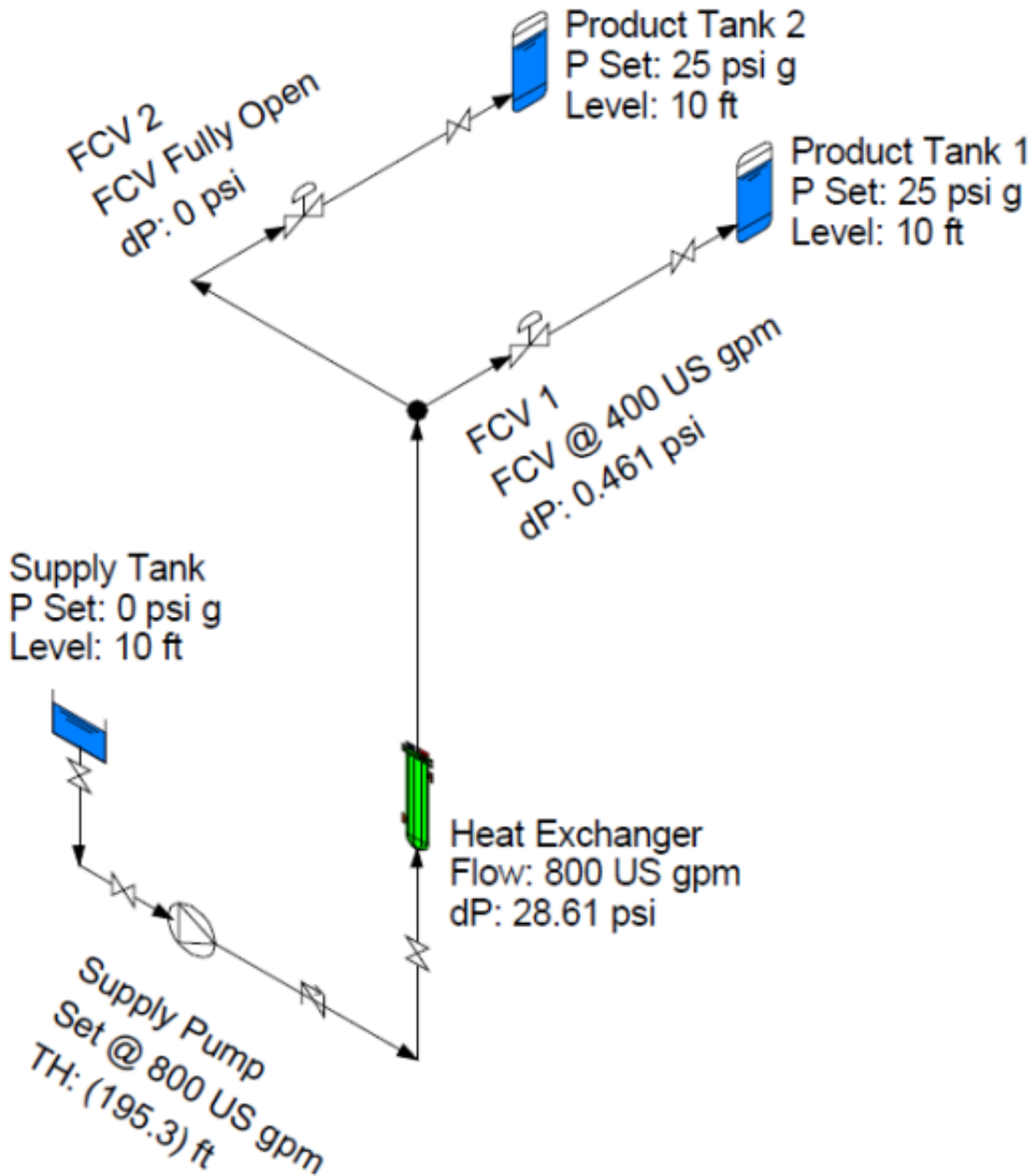
Product Tank 2
P Set: 25 psi g
Level: 10 ft

Product Tank 1
P Set: 25 psi g
Level: 10 ft

FCV 2
FCV Fully Open
dP: 0 psi

FCV 1
FCV @ 400 US gpm
dP: 0.461 psi

Supply Tank
P Set: 0 psi g
Level: 10 ft

Heat Exchanger
Flow: 800 US gpm
dP: 28.61 psi

Supply Pump
Set @ 800 US gpm
TH: (195.3) ft

Figure 3. Remote loop set to fully open.

PIPE-FLO models a fully open "undesigned" control as a valve with 0 psi across it, which may not be the case in reality depending on the type of valve it is (ball, butterfly, globe, etc). An undesigned control valve is one without valve data entered.

In addition, you may want to define the minimum desired dP across the control valve at the design conditions. In Figure 3, the pump's calculated Total Head does not include the actual or desired dP (head loss) across the control valve.

To take the actual or desired minimum differential pressure across a fully open control valve into account, you must replace the control valve with a fixed dP component, and then change it out once the pump is selected. Or you can split the pipe and add a fixed dP component, as shown in Figure 4. Set the differential pressure to the desired value (i.e. 10 psi) and set the control valve lineup setting to "Fully Open."
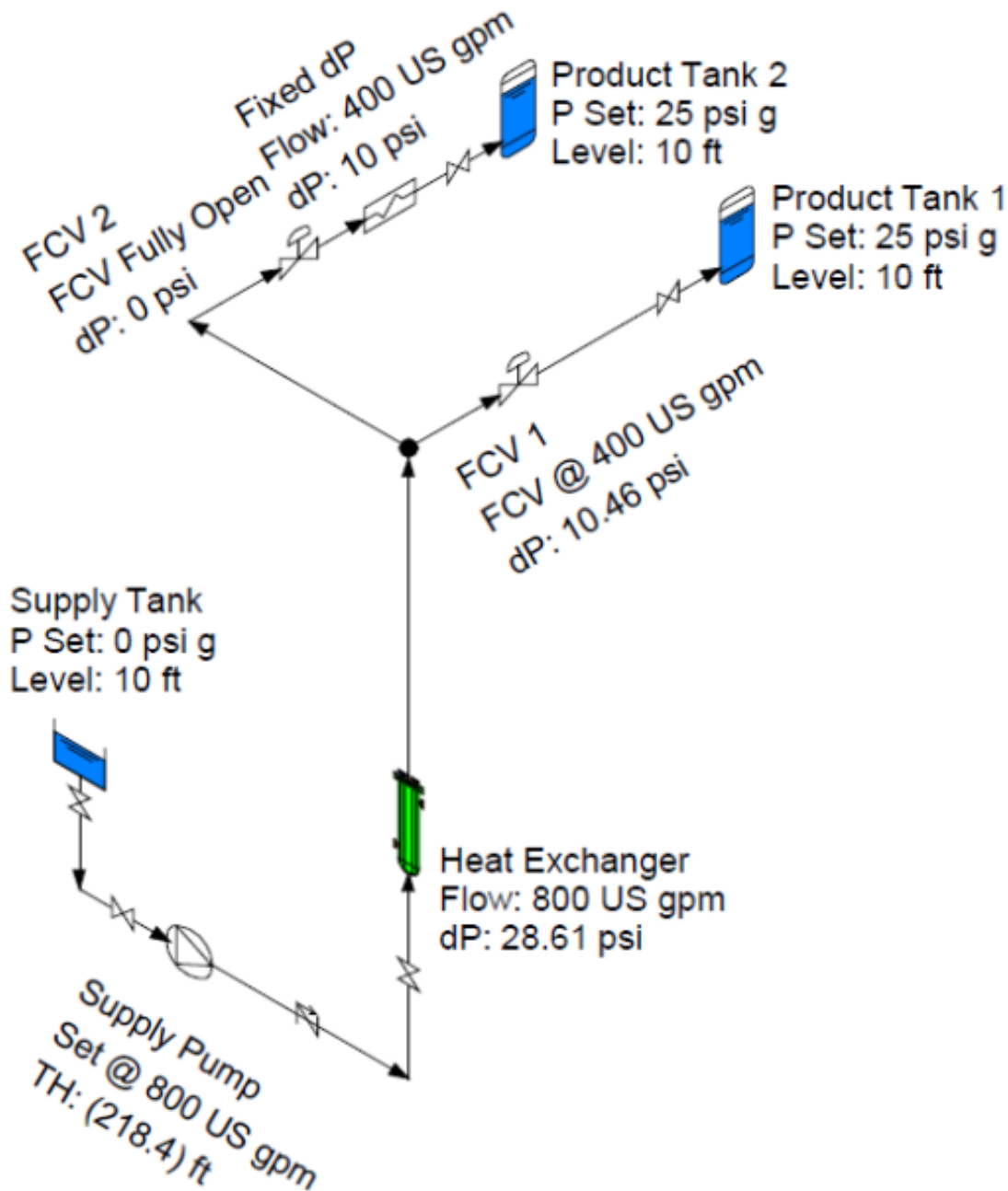
Figure 4. A fixed dP component added.

Now when the model is calculated as shown in Figure 4, the calculated Total Head of the Supply Pump takes into account the desired 10 psi dP across the control valve. The Total Head has increased to 218.4 ft, equivalent to the 10 psi increase across the control valve (23.1 ft = 10 psi x 2.31 ft/psi).

By adding the fixed dP component, you are ensuring that your calculated pump total head will be at least the minimum head needed to ensure that all your control valves will have the minimum required dP to control.

Now you are ready to select a pump for this system at the design conditions. A design margin may be added to the total head to account inaccuracies in system head loss. With a 5% design margin (an additional 11 feet of head), a design point search for a pump with 800 gpm and 230 ft of head is used to find a pump that meets the requirements of the system.

When the pump is selected and the "Fixed Speed Pump" option selected in the lineup settings, the pump curve will be used in the calculations of pressures and flows throughout the system. At this point, the fixed dP component should be removed and the control valve now set to the desired flow rate, as shown in Figure 5 (below). At the designed flow rate, the calculated dP across the control valve will be above the desired minimum of 10 psid. Notice that the design margin that was added (11 feet of head) shows up as additional pressure drop across the MHRL control valve (11 feet = 4.8 psi), resulting in a total pressure drop of 14.86 psi across the valve.

FCV 2
FCV @ 400 US gpm
dP: 14.86 psi

Product Tank 2
P Set: 25 psi g
Level: 10 ft

Fixed dP
P: 31.02 psi g

Product Tank 1
P Set: 25 psi g
Level: 10 ft

FCV 1
FCV @ 400 US gpm
dP: 15.32 psi

Supply Tank
P Set: 0 psi g
Level: 10 ft

Heat Exchanger
Flow: 800 US gpm
dP: 28.61 psi
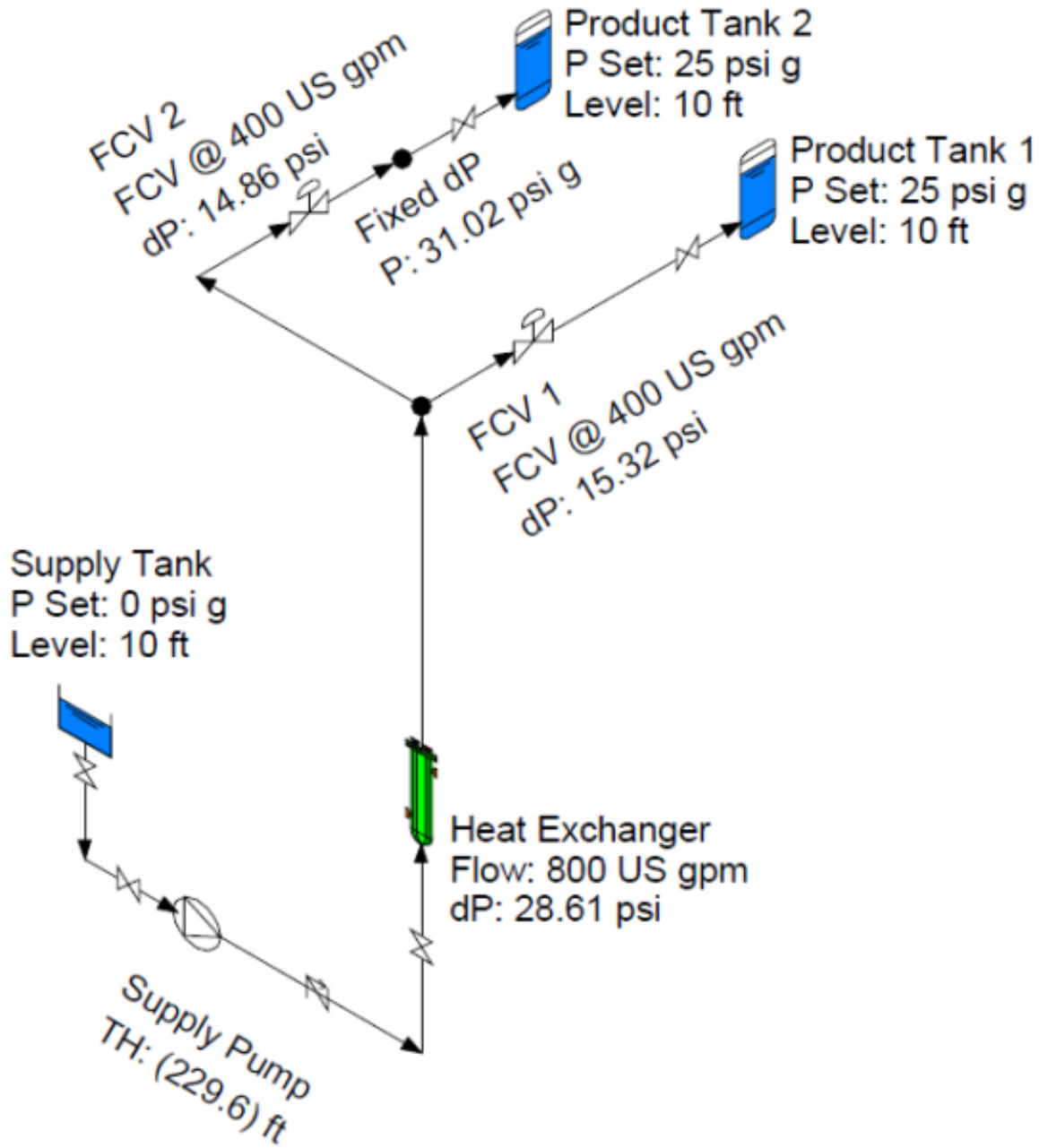
Supply Pump
TH: (229.6) ft

Figure 5. With a pump selected and the fixed 10 psid component removed, the pressure drop across the control valve remains above the desired minimum at the design flow rate.