# Chapter 6
# Pressure Piping Systems and Water Quality Analysis

## Problem 6.1

The ductile iron pipe network shown below carries water at 20°C. Assume that the junctions all have an elevation of 0 m and the reservoir is at 30 m. Use the Hazen-Williams formula ($C$ = 130) and the pipe and demand data below to perform a steady-state analysis and answer the following questions:

a) Which pipe has the lowest discharge? What is the discharge (in l/min)?

**P-3 has the lowest discharge,with 152 l/min.**

b) Which pipe has the highest velocity? What is the velocity (in m/s)?

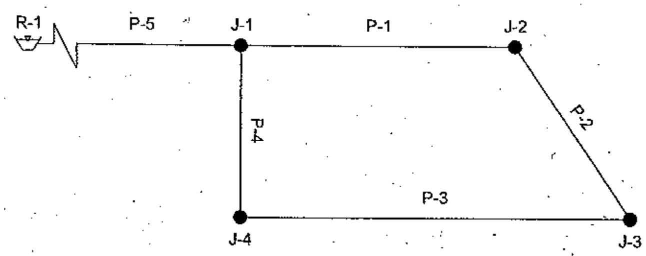
**P-4 has the highest velocity with 1.49 m/s.**

c) Calculate the problem using the Darcy-Weisbach equation ($k$ = 0.26 mm) and compare the results.

**Pipe P-3 still has the lowest discharge (144 l/min), and P-4 still has the highest velocity (1.47 m/s).**

d) What effect would raising the reservoir by 20 m have on the pipe flow rates? What effect would it have on the hydraulic grade lines at the junctions?

**Raising the reservoir would not have any effect on the pipe flow rates. The demands in the system are still the same (and there is only one source of water), so the flows and head losses will still balance the same way. The hydraulic grades, however, will be 20 m higher.**




*Schematic for Problem 6-1*

*Pipe and Junction Information for Problem 6-1*

| Pipe | Diameter (mm) | Length (m) |
|---|---|---|
| P-1 | 150 | 50 |
| P-2 | 100 | 25 |
| P-3 | 100 | 60 |
| P-4 | 100 | 20 |
| P-5 | 250 | 760 |

| Junction | Demand (l/min) |
|---|---|
| J-1 | 570 |
| J-2 | 660 |
| J-3 | 550 |
| J-4 | 550 |

## Problem 6-2

A pressure gage reading of 288 kPa was taken at J-5 in the pipe network shown below. Assuming a reservoir elevation of 100 m, find the appropriate Darcy-Weisbach roughness height (to the hundredths place) to bring the model into agreement with these field records. Use the same roughness value for all pipes. Pipe and junction data are shown below.

a) What roughness factor yields the best results?

**A roughness height of 0.19 mm results in the closest pressure at J-5. (Use the global adjustment factors in the Calculation dialog to temporarily test the model under changed conditions. Once the correct factor is determined, the changes can be made permanent by pressing the Apply button.)**

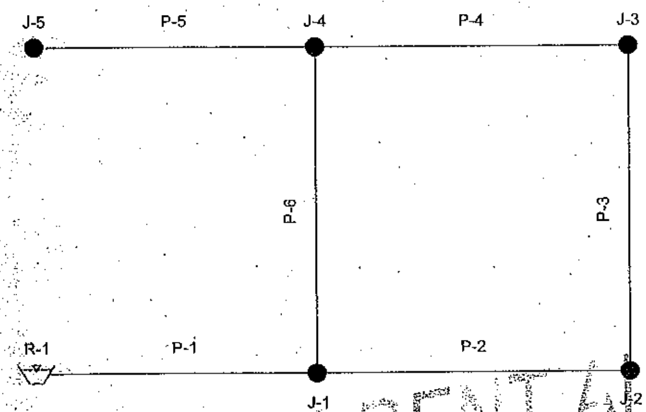
b) What is the calculated pressure at J-5 using this factor? **287.79 kPa**

c) Other than the pipe roughnesses, what other factors could cause the model to disagree with field-recorded values for flow and pressure?





**Incorrect junction elevations, incorrect reservoir elevation, incorrect demands, poor field measurements, and other factors can contribute to a model disagreeing with field records. This is an excellent time to discuss the importance of having complete, accurate data in order to create a complete, accurate model.**




*Schematic for Problem 6-2*

*Pipe and Junction Information for Problem 6-2*

| Pipe | Diameter (mm) | Length (m) |
|---|---|---|
| P-1 | 250 | 1,525 |
| P-2 | 150 | 300 |
| P-3 | 150 | 240 |
| P-4 | 150 | 275 |
| P-5 | 150 | 245 |
| P-6 | 200 | 230 |

| Junction | Elevation (m) | Demand (l/min) |
|---|---|---|
| J-1 | 55 | 950 |
| J-2 | 49 | 1,060 |
| J-3 | 58 | 1,440 |
| J-4 | 46 | 1,175 |
| J-5 | 44 | 980 |

## Problem 6-3

A distribution system is needed to supply water to a resort development for normal usage and emergency purposes (such as fighting a fire). The proposed system layout is shown in the following figure.

**The flow distribution has changed because of the limitation placed on pipe P-3. The pressures are lower at J-2 and J-3 because the increase in flow in Pipes P-1 and P-2 causes a greater head loss in those pipes.**

f) Why doesn't the pressure at J-1 change when the FCV is added?

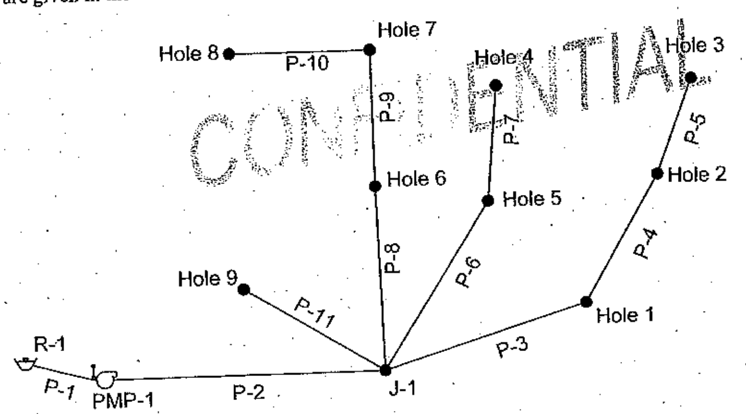
**The pressure at J-1 does not change because the flow through Pipes P-5 and P-6 does not change.**

g) What happens if you increase the FCV's allowable flow to 2,000 gpm? What happens if you reduce the allowable flow to zero?

**If you increase the allowable flow to 2,000 gpm, the results will be the same as if there were not a flow control valve on the pipe. To meet the demand, the needed flow through pipe P-3 is 408 gpm; therefore, a restriction of 2,000 gpm will not place any limitations on the system. If the flow control setting is zero, the results would be the same as if that pipe were closed.**

## Problem 6-5

A local country club has hired you to design a sprinkler system that will water the greens of their nine-hole golf course. The system must be able to water all nine holes at once. The water supply has a water surface elevation of 10 ft. All pipes are PVC ($C = 150$, use the Hazen-Williams equation to determine friction losses). Use a standard, three-point pump curve for the pump, which is at an elevation of 5 ft. The flow at the sprinkler is modeled using an emitter coefficient. The data for the junctions, pipes, and pump curve are given in the tables that follow. The initial network layout is shown below.




*Schematic for Problem 6-5*





*Junction and Pipe Information for Problem 6-5*

| Junction Label | Emitter Coefficient (gpm/psi$^{0.5}$) | Elevation (ft) |
|---|---|---|
| J-1 | -- | 10 |
| Hole 1 | 8 | 7 |
| Hole 2 | 10 | 7 |
| Hole 3 | 15 | 40 |
| Hole 4 | 12 | 5 |
| Hole 5 | 8 | 5 |
| Hole 6 | 8 | 15 |
| Hole 7 | 10 | 20 |
| Hole 8 | 15 | 10 |
| Hole 9 | 8 | 12 |

| Pipe Label | Diameter (in) | Length (ft) |
|---|---|---|
| P-1 | 4 | 10 |
| P-2 | 4 | 1,000 |
| P-3 | 4 | 800 |
| P-4 | 3 | 750 |
| P-5 | 3 | 500 |
| P-6 | 3 | 700 |
| P-7 | 2 | 400 |
| P-8 | 4 | 800 |
| P-9 | 3 | 500 |
| P-10 | 2 | 400 |
| P-11 | 2 | 500 |

*Pump Information for Problem 6-5*

| Head (ft) | Flow (gpm) |
|---|---|
| 170 | 0 |
| 135 | 300 |
| 100 | 450 |



a) Determine the discharge at each hole.

| Junction Label | Discharge (gpm) |
|---|---|
| Hole 1 | 39 |
| Hole 2 | 44 |
| Hole 3 | 33 |
| Hole 4 | 47 |
| Hole 5 | 38 |
| Hole 6 | 36 |
| Hole 7 | 38 |
| Hole 8 | 49 |
| Hole 9 | 35 |

b) What is the operating point of the pump?

**The pump is operating at 361 gpm at 122 ft.**