ME 561 – Assignment 2

Water Supply System Design

**Due Date:**

**Prepared by:**

# Instructions

* You must submit work that is reflective of your own individual efforts.
* Include your name and student ID on the front page.
* Please fill in the necessary information as listed. You may report on additional information if you wish. You may include separate files, as appendices for supporting information.
* Please include any references used. If there are any recommendations for different components, please also include those.
* Be sure to list all assumptions used in the analysis.

# Resources

ME 561 - Water Supply System Design Assignment 2

Appendix A: Pipe Sizing Chart

Appendix B: Some Suggested K-factors

Appendix C: Moody Diagram

Appendix D: Pump Data Sheets

Appendix E: Pump Cost Sheets

# Flow Analysis

## Flow Rate [1.5 marks]

The demand flow rate can be obtained for each fixture based on the fixture units. Based on this information, determine the flow rate for each fixture and pipe. Insert all calculations and supporting information with the assignment submission.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fixture** | **Fixture Units** | **Demand Flow Rate (gpm)** | **Demand Flow Rate (m3/s)** |
| Kitchen Sink | 2 | 2 | 0.000126 |
| Washroom Sink | 1 | 1 | 6.309e-5 |
| Washing Machine | 3 | 3 | 0.000189 |
| Toilet | 3 | 3 | 0.000189 |
| Shower | 2 | 2 | 0.000126 |
| Water Supply System | 14 | 11 | 0.000694 |
| Dishwasher | 3 | 3 | 0.000189 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pipe** | **Fixture Units** | **Flow Rate (gpm)** | **Flow Rate (m3/s)** | **Comment** |
| P1 | 14 | 11 | 0.000694 | Carries flow to house |
| P2 | 14 | 11 | 0.000694 | Carries flow to house |
| P3 | 14 | 11 | 0.000694 | Carries flow to house |
| P4 | 14 | 11 | 0.000694 | Carries flow to house |
| P5 | 14 | 11 | 0.000694 |  |
| P6 | 9 | 9 | 0.000568 |  |
| P7 | 8 | 8 | 0.000504 |  |
| P8 | 5 | 5 | 0.000315 |  |
| P9 | 2 | 2 | 0.000126 |  |
| P10 | 2 | 2 | 0.000126 | Shower pipe elevated (Figure 3) |
| P11 | 2 | 2 | 0.000126 |  |
| P12 | 3 | 3 | 0.000189 |  |
| P13 | 3 | 3 | 0.000189 |  |
| P14 | 1 | 1 | 6.309e-5 |  |
| P15 | 5 | 5 | 0.000315 |  |
| P16 | 3 | 3 | 0.000189 |  |
| P17 | 2 | 2 | 0.000126 |  |

## Pipe Sizing [2.5 marks]

Include all calculations, interpolations, explanations, justifications, and supporting information with the assignment submission.

Consider the pipe sizing inside the home to start with, based on the flowrate demand. Consider the pipe sizing outside the home based on the flowrate demand inside the home and state any other assumptions or justifications in guiding your selection. Due to simplification reasons, please select Type K smooth copper piping for the exterior as well.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pipe** | **Flow Rate (gpm)** | **Diameter (in)** | **Diameter (m)** | **Justification Comments** |
| P1 | 11 | 2 | 0.0508 |  |
| P2 | 11 | 2 | 0.0508 |  |
| P3 | 11 | 2 | 0.0508 |  |
| P4 | 11 | 2 | 0.0508 |  |
| P5 | 11 | 2 | 0.0508 |  |
| P6 | 9 | 1 | 0.0254 |  |
| P7 | 8 | 1 | 0.0254 |  |
| P8 | 5 | 0.75 | 0.0190 |  |
| P9 | 2 | 0.5 | 0.0127 |  |
| P10 | 2 | 0.5 | 0.0127 |  |
| P11 | 2 | 0.5 | 0.0127 |  |
| P12 | 3 | 0.5 | 0.0127 |  |
| P13 | 3 | 0.5 | 0.0127 |  |
| P14 | 1 | 0.5 | 0.0127 |  |
| P15 | 5 | 0.75 | 0.0190 |  |
| P16 | 3 | 0.5 | 0.0127 |  |
| P17 | 2 | 0.5 | 0.0127 |  |

## Pump Head [6 marks]

Perform head calculations for the following **Scenario 1:** based on a demand scenario where only the shower fixture and washroom sink are operating at maximum capacity, with everything else being turned off. State any assumptions; show your calculations. For your solution:

### Highlight the path of the fluid by listing the pipes that will see fluid motion in steady state.

### Calculate the Pipe Friction Losses [m] for the relevant pipes in the path of the fluid.

You may create your own table to report such; the table below is for guidance purposes. Show intermediary calculation steps in your submission. State any assumptions and references to fluid properties.

|  |  |  |  |
| --- | --- | --- | --- |
| **Pipe** | **[Intermediary Calculations]** | **Pipe Head Loss [m]** | **With fixtures off** |
| P1 |  | 5.41 | 5.04 |
| P2 |  | 1.09 | 0.11 |
| P3 |  | 0.33 | 0.034 |
| P4 |  | 0.062 | 0.0064 |
| P5 |  | 0.50 | 0.05 |
| P6 |  | 0.23 | 0.034 |
| P7 |  | 0.12 | 0.01 |
| P8 |  | 0.12 | 0.025 |
| P9 |  | 0.34 | 0.34 |
| P10 |  | 0.23 | 0.23 |
| P11 |  | 1.94 | 1.94 |
| P12 |  | 0.57 | 0 |
| P13 |  | 0.29 | 0 |
| P14 |  | 0.042 | 0.042 |
| P15 |  | 0.51 | 0 |
| P16 |  | 0.69 | 0 |
| P17 |  | 0.49 | 0 |

### Calculate the Fittings Head Losses [m] for the fittings in the path of the fluid.

In doing so, first state a table for all your Fitting Coefficient values and any assumptions you have made.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Fitting** | **Normal Function** | **Effective Function** | **Effective K Factor** | **[Intermediary Calculations […]** | **Fittings Head Losses [m]** |
| F1 | 90° Elbow |  |  | 0.37 | 0.015 |
| F2 | 90° Elbow |  |  | 0.37 | 0.015 |
| F3 | 90° Elbow |  |  | 0.37 | 0.015 |
| F4 | Tee |  |  | 0.37 | 0.012 |
| F5 | Tee |  |  | 0.37 | 0.012 |
| F6 | Tee |  |  | 0.25 | 0.005 |
| F7 | Tee |  |  | 0.44 | 0.018 |
| F8 | 90° Elbow |  |  | 1.00 | 0.112 |
| F9 | 90° Elbow |  |  | 1.00 | 0.112 |
| F10 | 90° Elbow |  | 0 |  | 0 |

### Based on Bernoulli’s equation, determine the Pump Head necessary to produce the required pressure and flowrate at the shower outlet.

State all your assumptions. Include all calculations and supporting information in your submission; some guidelines below. P2 = 206842.719 pa

|  |  |
| --- | --- |
| **Variable** | **Value (m)** |
| **Scenario 1** |
| Initial Pressure Head at point P1 | 5.165 |
| Initial Velocity Head at point P1 | 0.096 |
| Initial Elevation Head at point P1 | -5 |
| Pipe Head Losses | 6.08 |
| Fitting Head Losses | 0.305 |
| Final Pressure Head at point P2 | 21.08 |
| Final Velocity Head at point P2 | 0.05 |
| Final Elevation Head at point P2 | 1.75 |
| Pump Head | 29.27 |
| Need 41.65psi |  |

## Pump Selection [3 marks]

Based on cost, maintenance, and efficiency, use a decision matrix to select a suitable pump to meet the scenario. Justify the weighting for each criterion, keeping in mind the specific application. You may include other criteria as desired but it is optional to do so. Supporting materials are provided for centrifugal, submersible, and jet pumps to assist in the pump selection and cost analysis. You are welcome to analyze pumps outside the ones provided in the supporting materials, but this is also optional. Include any references used to support your analysis.

### Pump Cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Pump Type** | **Pump Power (HP)** | | **Cost ($)** | |
| **Scenario 1** | **Scenario 2**  (Not in Scope) | **Scenario 1** | **Scenario 2**  (Not in Scope) |
| Centrifugal | 3/4 |  | 759 |  |
| Submersible | 1/2 |  | 1067 |  |
| Jet | 1/2 |  | 620 |  |

### Efficiency

|  |  |
| --- | --- |
| **Pump Type** | **Comments** |
| Centrifugal |  |
| Submersible |  |
| Jet |  |

### Maintenance

|  |  |
| --- | --- |
| **Pump Type** | **Comments** |
| Centrifugal |  |
| Submersible |  |
| Jet |  |

### Decision Matrix

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Weighting (%)** | **Justification** |
| Cost |  |  |
| Efficiency |  |  |
| Maintenance |  |  |

# Discussion [2 marks]

## Based on the results found, briefly discuss the expected design changes if the water level in the well was 0.5 m higher.

## Consider if the residential home had two floors and all the current fixtures were located on the second floor, with no fixtures on the first floor. Would your selected pump be able to perform in the scenario selected?

## Consider if all the fixtures were open. What do you think may happen and how will it affect the pump efficiency?

## Would positive displacement pumps be more suitable for this application? Discuss and compare this fluid circuit application with typical fluid power applications.

# Marking Scheme

|  |  |
| --- | --- |
| **Criteria** | **Mark** |
| 3.1 Flow Rate Analysis | 1.5 |
| 3.2 Pipe Sizing | 2.5 |
| 3.3 Pump Head | 6 |
| 3.4 Pump Selection | 3 |
| 4. Discussion | 2 |
| **Total** | **15** |