Design Problem 1 – Pump and Piping Design

1. Objectives
2. Problem statement.
3. Submission requirements.

Objective

The objective of Problem 1A is to design and optimize a pipeline and pump system.

Problem Statement

The feed to a multi-component distillation is shown in Table 1 below. This feed liquid must be delivered to a distillation column by pipeline. Your assignment is to design the piping and pump to deliver this feed to the column. That is, you will determine the size and cost of the pipeline connecting the pump outlet to the column, and you will determine the size and price of the pump. The pipeline on the feed side (upstream) of the pump will not be considered in this assignment. You will also determine the purchased and installed costs for the pump, pipe, fittings, insulation, and hangers, as well as the operating energy costs for one year of operation. Finally, your system must be *optimized* for peak economic efficiency. That is, you must determine the optimum economic pipe diameter and corresponding nominal pipe size. Your design will be subject to the additional constraints described below.

Table DP1A-1. Feed Component Flow Rates (298 K and 202.650 kPa)

Component	Feed Rate, lb-mol/h
Toluene	7.320
Naphthalene	23.985
Biphenyl	252.525
Diphenylenemethane (Fluorene)	15.435
Phenanthrene	11.535
M-Terphenyl	28.785
Total	339.59

Constraints and Additional Information

- You will *not* be designing the distillation column or column internals (trays, shell, condenser, reboiler). This has already been designed by another group.
- A sketch of the layout is provided in the Addendum on page 3, showing the following isometrics:
  - The column design group has determined that the column contains 10 trays with 3 feet between each tray (3-ft tray spacing).
  - The bottom of the column is on a pedestal 6 feet off the ground.
  - Inside the column, below the bottom tray, there is a six-foot vertical space for liquid disengagement from the boil-up vapors.

- The feed must enter on the third tray from the top 33 feet above ground level at **298 K and 353.5 kPa**.
- The liquid level in the feed vessel is controlled 14 feet above the ground.
- Total pipe length must be estimated from the design layout. The pump must be mounted at floor-level and be 120 feet away from the column.
- The line has twelve 90° standard elbows, two gate valves, and three globe valves.

- All piping and fittings are Schedule 40 welded carbon steel (commercial steel).
- Any cost data taken from the textbook or website must be multiplied by an appropriate factor to correct for the age of the data.
- CHEMCAD cost information must be corrected by entering the current Chemical Engineering Plant Cost Indices. Values are entered under "Tools," then "Costing."
- Pipe costs can be found in the PTW text book or on the PTW web site.
- Fittings costs are in the "1979 Pipe & Fitting Prices" document found in your SharePoint (Fig. 13-4, PTW, 3rd ed., p. 529).
- Piping must be painted.
- Pump and motor costs must be determined in CHEMCAD. The pump is centrifugal, case steel and explosion proof. The motor is 3600 rpm, and the pump is 79% efficient.
- Installed costs are 2.8 times the delivered equipment cost.
- Energy cost is $0.133 per kWh and should be based on one year of operation (365d=1yr).

Submission Requirements

1. An Excel spreadsheet (printed, with cover sheet) that includes:

   a. Diameter, purchased and installed costs in January 2022 for pipe, elbows, valves, and paint.

   c. Purchased and installed cost of pump and motor in January 2022.

   d. Pump NPSH, power, energy, and energy cost for 1 year.

   d. Total cost of installed equipment and energy.

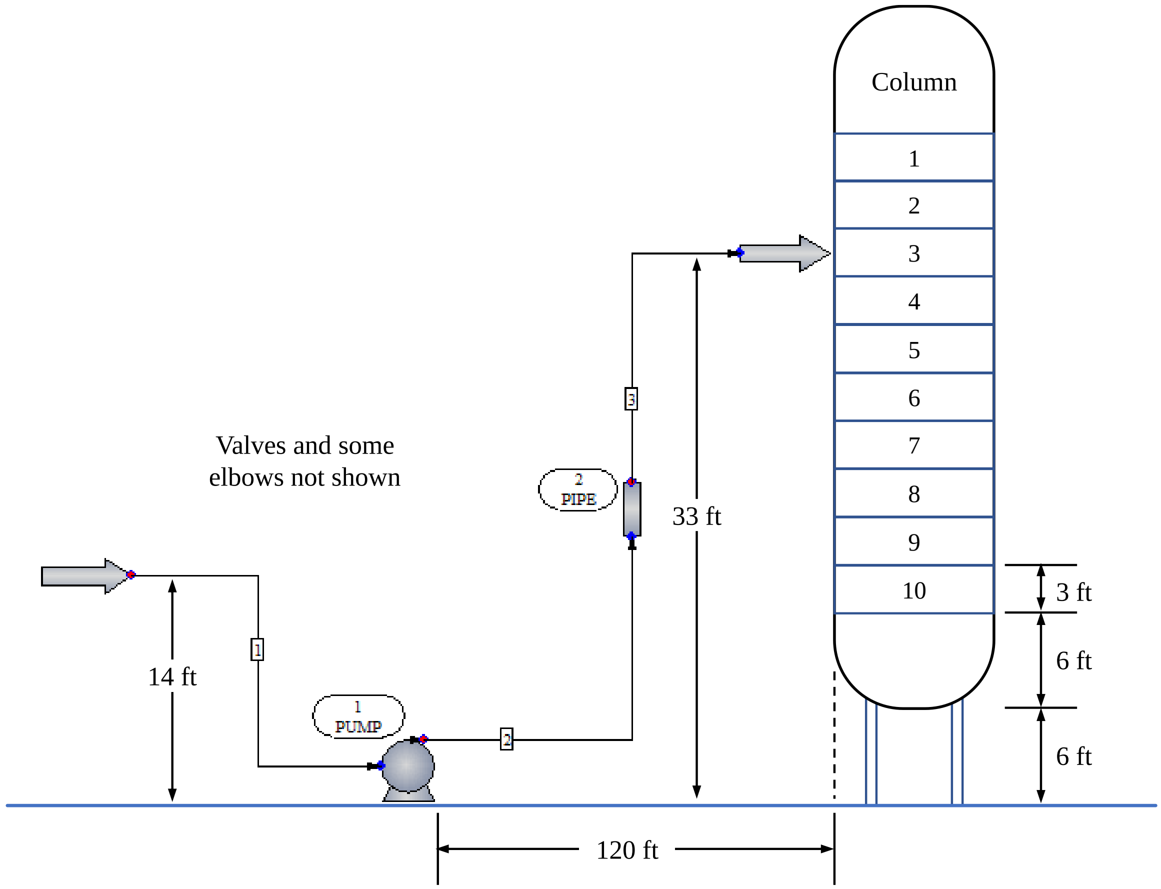
   e. An Excel template is provided in your SharePoint directory. Complete the template for your submission.

2. A working CHEMCAD model of the process (piping and pump only).

3. Evidence that your design has been *optimized*.

4. All electronic files must be in your SharePoint in the DP1 subdirectory.

Addendum



Column
1
2
3
4
5
6
7
8
9
10
Valves and some
elbows not shown
2
PIPE
1
PUMP
33 ft
14 ft
3 ft
6 ft
6 ft
120 ft