Project 2:
Design of a Crude Oil Delivery System

Your design team has been awarded the task of designing a crude oil delivery system. Ocean-going oil tankers deliver their cargo of 35º API crude oil to a port near Vancouver, BC (see Fig. 1). The oil is off-loaded by transferring it to a storage tank. The crude oil is then delivered from the storage tank to two different locations, each having their own storage tank (see Fig. 2).

Main Project Objectives

1. Determine the maximum continuous flow rates of crude oil that can be extracted from the tanks at points 7 & 8 (see Fig. 2) which will obviously be based on the size of oil tankers used (assume they are all the same size and capacity) and the length of time taken to off-load the oil cargo and connect up the next tanker.
2. Determine the effect of variable tank levels on the tank outflows. Also take into account the oil tankers buoyancy, i.e., the level of the ship changes in the water as crude oil is off-loaded.
3. Determine the required nominal pipe diameters for all pipes and type of pipe material. Initially assume an economic flow velocity in the range 1.4–2.8 ft/s but further research may be required to find better values for 35º API crude oil.
4. Determine any unknown pipe lengths and nominal diameters such as $L_{1\text{-}2}$, $L_{4\text{-}5}$, etc..
5. Design all the storage tanks including thickness and type of wall material, height, diameter, etc.. Specify the holding capacities at full capacity.
6. It may be necessary to use pumps in series and/or parallel so specify the configuration of the pumps at each location and give the type of pump, it's impeller diameter and speed of operation.
7. Verify that the net-positive head requirements are met at each pump inlet.
8. Determine the maximum permissible elevation of point 3 so that cavitation does not occur in the crude oil. Point 3 may need to higher than 200 ft to clear obstacles etc..
9. Determine what happens to the delivery flows throughout the system and the effect on the tank levels during the following emergency shutdown situations:
   a) Supply pipe B is completely blocked for 24 hours and all other flows continue.
   b) Supply pipe C is completely blocked for 24 hours and all other flows continue.
   c) Supply pipe A is completely blocked for 24 hours and all other flows continue.
10. Determine the number of valves, their type, and locations in the system, required to handle the emergency situations listed in point 9. Additionally, valves and/or check-valves may be required to prevent reverse flow etc..
11. Evaluate the cost of electrical power required to drive all pumps for one full year. Include the variable cost of electricity based on time-of-day usage. Ignore the emergency scenarios.
12. Document your project results in <u>SI units</u> in a written report. Include engineering drawings.

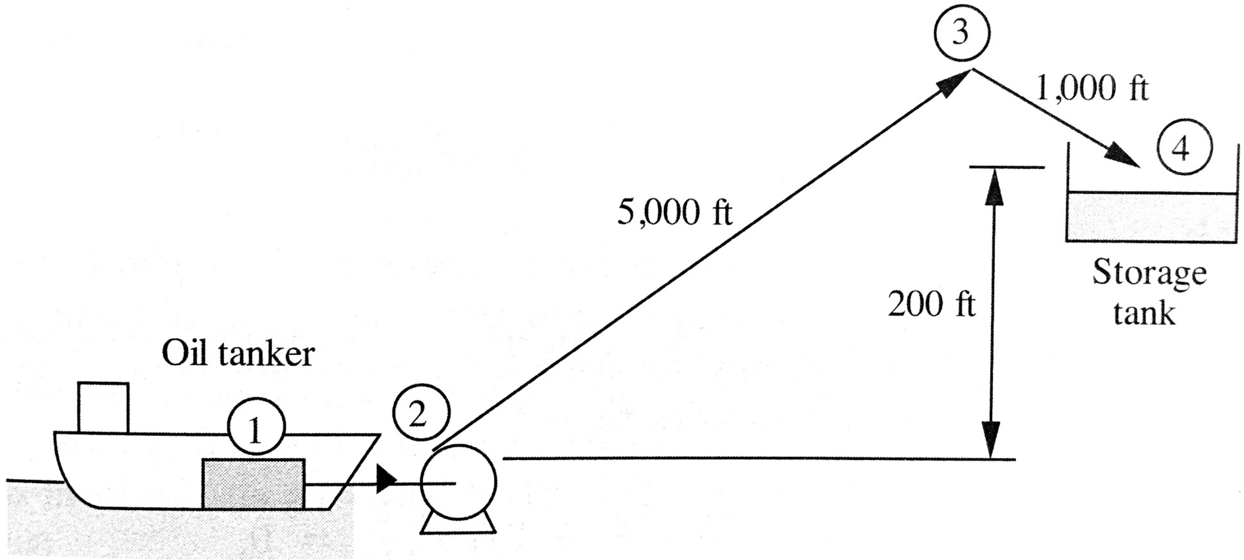

Figure 1. Phase one of the project involves an oil tanker off-loading it's crude oil cargo (point 1) into a storage tank (point 4). As soon as the tanker's cargo has emptied, the tanker leaves port and another tanker moves into place to off-load it's oil cargo. This off-loading cycle continues 24 hours per day, 7 days per week, all year long. [Ref. 1, Fig. E3.5 (modified), p. 147].

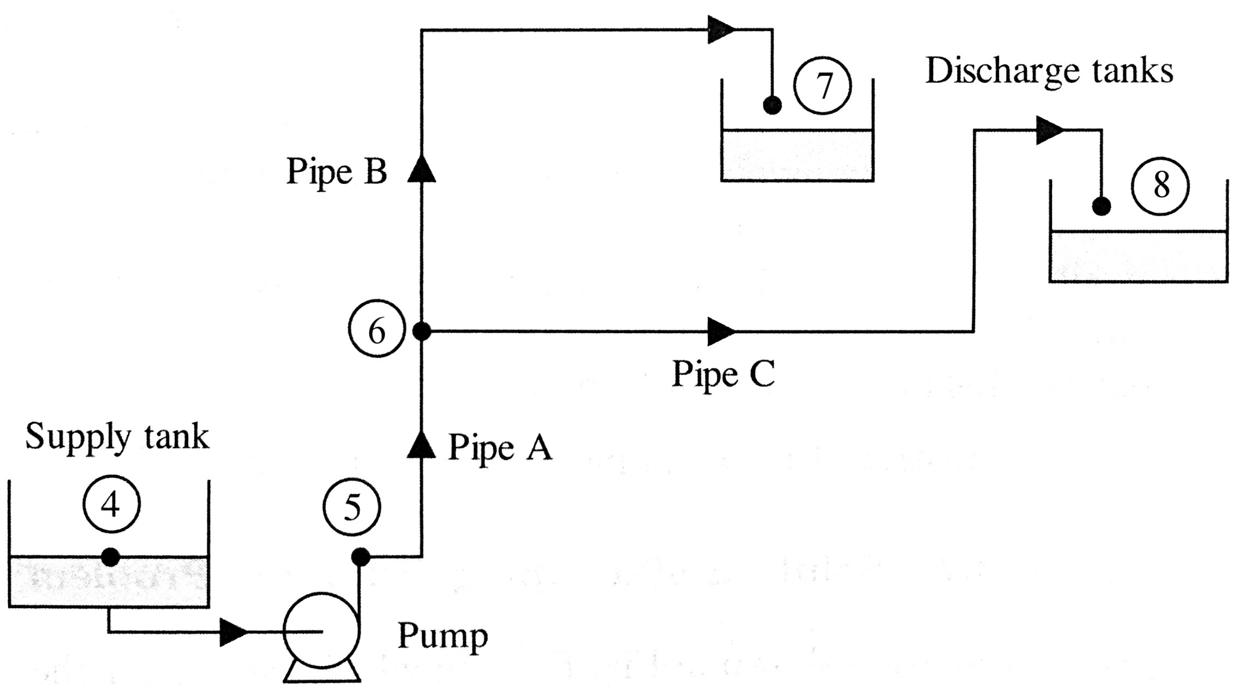

Figure 2. Phase two of the delivery system involves transferring crude oil from the main supply tank (point 4) to two different locations (see points 7 & 8). The supply tank at point 4 is the same one as shown in Fig. 1. The total delivery flow in pipe A is divided up such that pipe B carries 40% of the total and pipe C carries the other 60%. Known pipe lengths are $L_{5\text{-}6}$ = 13,000 ft, $L_{6\text{-}7}$ = 3300 ft, and $L_{6\text{-}8}$ = 6600 ft. Known elevations are z_4 = 200 ft (at full capacity), z_6 = 300 ft, z_7 = 700 ft, and z_8 = 500 ft. [Ref. 1, Fig. E3.7 (modified), p. 166].

References

1. Wilkes, J. O. (2006). *Fluid Mechanics for Chemical Engineers* (2^{nd} ed.) *with Microfluidics and CFD*. Toronto, ON: Pearson.