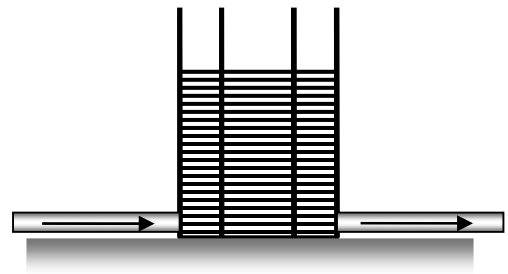
Example

On the east coast, natural gas is frequently stored in large flexible tanks that can expand and contract while maintaining a relatively constant pressure. The walls of the tank are made of a flexible accordion membrane, and the roof and floor of the tank are rigid. As the tank fills up the roof of the tank "floats" up. The vertical tank has diameter d = 50 ft and a height h which change from 5 ft to 30 ft. Under normal operating conditions, the temperature and pressure inside the tank is uniform and constant. The density of the natural gas in the tank under these conditions is ρ = 0.12 lbm/ft^3.



A flexible natural gas tank

(a) Under one set of operating conditions, h = 10 ft and natural gas is flowing into the tank at 470 lbm/min and flowing out of the tank at 235 lbm/min, and natural gas has a density ρ = 0.12 lbm/ft^3.

- Is the roof of the tank moving up or down? How fast?
- How far will it move in 5 minutes?

(b) On another day, the tank operators observe a drop in the roof height h even though all tank valves are shut and they are worried there could be a leak. Or it might just be caused be the change in temperature due to the cold snap. Initially, the roof height h_1 = 10 ft when the air (and natural gas) temperature T_1 = 40°F (500°R). And after the cold snap, the temperature T_2 = 10°F (470°R).

If the tank pressure is uniform and constant and natural gas (methane) can be modeled as an ideal gas with R_{methane} =96.3 ft-lbf/lbm-$^{\text{o}}$R, determine the new roof height after the cold snap.