1. A tank contains 8733 lbs of water at room temperature. How many hours would it take to empty the tank if a pump removes 2.5 gallons of water from the tank every minute.

First, let's figure out how many gallons of water we have.

$$V = \frac{w}{\gamma} = \frac{8733 \text{ lb}}{62.21 \text{ lb/ft}^3} = 140.4 \text{ ft}^3 \times \left(\frac{7.48 \text{ gal}}{\text{ft}^3}\right) = 1050 \text{ gal}$$

If we remove 2.5 gallons of water every minute it would take

$$(1050 \text{ gal}) / (2.5 \text{ gal/ min}) = 420 \text{ min} \times \left(\frac{1 \text{ hr}}{60 \text{ min}}\right) = 7 \text{ hr}$$

2. If 400 L/min of fluid flows through a DN 50 Schedule 80 steel pipe what is the resulting average velocity (in m/s) of flow?

$$A_{\text{flow}} = 1905 \text{ mm}^2 = 1.905 \times 10^{-3} \text{ m}^2$$

$$Q = 400 \text{ L}/\min \times \frac{1 \text{ m}^3/s}{60,000 \text{ L}/\min} = 6.67 \times 10^{-3} \text{ m}^3/s$$

$$v = \frac{Q}{A_{\text{flow}}} = \frac{6.67 \times 10^{-3} \text{ m}^3/s}{1.905 \times 10^{-3} \text{ m}^2} = 3.5 \text{ m}/s$$

3. What is the smallest size standard Schedule 40 steel pipe that would carry 2.80 L/min of oil with a an average flow velocity below 0.3 m/s? Report your answer as a metric Nominal Pipe Size (DN).

First find the area required to transport the fluid exactly as specified.

$$Q = 2.80\ \mathrm{L}/\min \times \frac{1\ \mathrm{m}^3/s}{60,000\ \mathrm{L}/\min} = 4.67 \times 10^{-5}\ \mathrm{m}^3/s$$

$$A = \frac{Q}{v} = \frac{4.67 \times 10^{-5}\ \mathrm{m}^3/s}{0.3\ \mathrm{m}/s} = 1.56 \times 10^{-4}\ \mathrm{m}^2 = 155.56\ \mathrm{mm}^2$$

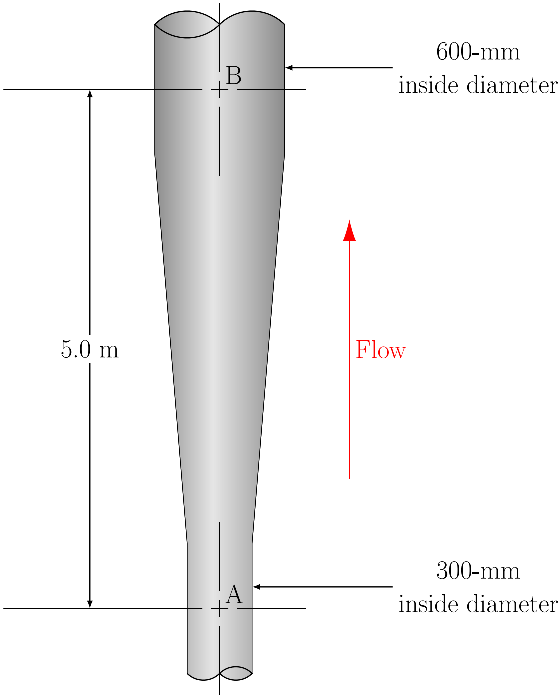
If we made the area any smaller the flow velocity would go above the 0.3 m/s. We therefore must go with DN15 pipe which has an area of 196 mm^2. If we went with the DN10 the flow velocity would be 0.38 m/s. Going with the DN15 results in a flow velocity of 0.24 m/s.

4. An aneurysm is an abnormal enlargement of a blood vessel such as the aorta. A patient's abdominal CT scan reveals an abnormal abdominal aortic diameter of 5.0 cm compared to their normal aortic diameter of 2.5 cm. If blood of density 1060 $\mathrm{kg/m^3}$ travels through the normal portion of the aorta at a speed of 40 cm/s by how much does the pressure in the abnormal region exceed that of the normal region? Report your answer in kPa.

$$\Delta p = \frac{\rho}{2}\left(v_1^2 - v_2^2\right) = \frac{\rho v_1^2}{2}\left(1 - \left(\frac{d_1}{d_2}\right)^4\right)$$

$$\Delta p = 0.5\left(1060\ \mathrm{kg/m^3}\right)\left(0.40\ \mathrm{m}/s\right)^2\left(1 - 0.0625\right) = 79.5\ \mathrm{Pa}$$

5. Turpentine is flowing at 0.45 m^3/s in the fabricated tube shown below. If the pressure before the enlargement at A is 500 kPa what is the pressure at point B?



$$p_B = p_A + \frac{\rho}{2}\left(v_A^2 - v_B^2\right) - \gamma(z_B - z_A)$$

$$v_A = 6.37 \text{ m}/s \qquad v_B = 1.59 \text{ m}/s$$

$$p_B = 500 \text{ kPa} + \frac{870}{2}\left(6.37^2 - 1.59^2\right) - 8.53(5 \text{ m})$$

$$p_B = 500 \text{ kPa} + 16.55 \text{ kPa} - 42.64 \text{ kPa} = 474 \text{ kPa}$$

6. Octane is flowing at 10 gpm from a standard 1-in Schedule 40 steel pipe to a standard 2-in Schedule 40 steel pipe. The pipes are horizontal. What is the difference in pressure (in psi) between the two pipes?

$$v_{1\text{ in}} = 10\text{ gpm}\frac{1\text{ ft}^3/s}{449\text{ gpm}}\frac{1}{0.006002\text{ ft}^2} = 3.71\text{ ft}/s$$

$$v_{2\text{ in}} = 10\text{ gpm}\frac{1\text{ ft}^3/s}{449\text{ gpm}}\frac{1}{0.02330\text{ ft}^2} = 0.956\text{ ft}/s$$

$$\Delta p = \frac{\rho}{2}\left(v_1^2 - v_2^2\right)$$

$$\Delta p = 0.5 \times 1.36 \times (3.71^2 - 0.956^2)\text{ slug}/(\text{ft}\cdot s^2)$$

$$= 8.74\text{ lb}/\text{ft}^2 = 0.06\text{ psi}$$