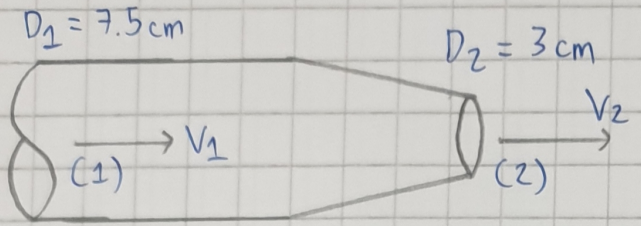
Nguyen Xuan Binh 887799 Round 3 Problem 3

A fire hose puzzle has a diameter of 3cm. According to some fire codes, the nozzle must be capable of delivering at least 750 liters/min. If the nozzle is attached to a 7.5 cm diameter hose, what pressure must be maintained just upstream of the nozzle to deliver this flow rate?



$D_1 = 7,5cm = 0.075m$

$D_2 = 3cm = 0.03m$

$Q_1 = Q_2 = 750 \text{ liters/min} = 0,0125 \ m^3/s$

Bernoulli equation: $p_1 + \frac{1}{2}\rho_{water} v_1^2 + \rho_w g z_1 = p_2 + \frac{1}{2}\rho_w v_2^2 + \rho_w g z_2$

We have: $z_1 = z_2$. Water is delivered outside the nozzle as free jet $\Rightarrow$ all pressure is converted to kinetic energy $\Rightarrow p_2 = 0$

$\Rightarrow p_1 + \frac{1}{2}\rho_w v_1^2 = \frac{1}{2}\rho_w v_2^2$ (1)

Confined flows conservation: $Q_1 = Q_2 \Rightarrow Q_{1min} = Q_{2min} = 0,0125 \ m^3/s$

$\Rightarrow v_1 A_1 = v_2 A_2 = 0,0125 \Rightarrow \begin{cases} v_1 = 0.0125/(\pi \cdot 0,0375^2) = 2.829 \ m/s \\ v_2 = 0.0125/(\pi \cdot 0,015^2) = 17.684 \ m/s \end{cases}$

From (1) $\Rightarrow p_1 = \frac{1}{2}\rho_w v_2^2 - \frac{1}{2}\rho_w v_1^2 = \frac{1}{2}(1000 kg/m^3)(17.684^2 - 2.829^2)$

$\approx 152360,3075 \ Pa$

$\Rightarrow$ Pressure upstream necessary to deliver flow rate of 750 liters/min is

$p_1 \approx 152,36 \ kPa$