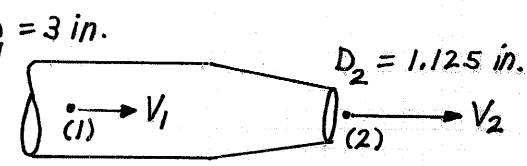
3.18

3.18 A fire hose nozzle has a diameter of $1\frac{1}{8}$ in. According to some fire codes, the nozzle must be capable of delivering at least 250 gal/min. If the nozzle is attached to a 3-in.-diameter hose, what pressure must be maintained just upstream of the nozzle to deliver this flowrate?



$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

with $z_1 = z_2$, $p_2 = 0$

and $Q = \left(250 \frac{gal}{min}\right)\left(231 \frac{in^3}{gal}\right)\left(\frac{1\ ft^3}{1728\ in^3}\right)\left(\frac{1\ min}{60\ s}\right) = 0.557 \frac{ft^3}{s}$

Thus,

$$p_1 = \frac{\gamma}{2g}\left[V_2^2 - V_1^2\right] \quad \text{where} \quad V_2 = \frac{Q}{A_2} = \frac{0.557 \frac{ft^3}{s}}{\frac{\pi}{4}\left(\frac{1.125}{12}\right)^2 ft^2} = 80.7 \frac{ft}{s}$$

and

$$V_1 = \frac{Q}{A_1} = \frac{0.557 \frac{ft^3}{s}}{\frac{\pi}{4}\left(\frac{3}{12}\right)^2 ft^2} = 11.34 \frac{ft}{s}$$

so that with $\frac{\gamma}{g} = \rho$

$$p_1 = \frac{1}{2}\left(1.94 \frac{slugs}{ft^3}\right)\left[80.7^2 - 11.34^2\right] \frac{ft^2}{s^2}$$

$$= 6190 \frac{lb}{ft^2} = \underline{\underline{43.0\ psi}}$$