P3.134 For the 40°C water flow in Fig. P3.134, estimate the volume flow through the pipe, assuming no losses; then explain what is wrong with this seemingly innocent question. If the actual flow rate is Q = 40 m^3/h, compute (a) the head loss in ft and (b) the constriction diameter D which causes cavitation, assuming that the throat divides the head loss equally and that changing the constriction causes no additional losses.

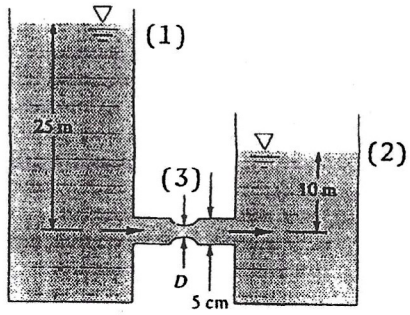

Fig. P3.134

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

Energy (1) – (2)

$0 + 0 + 25 \neq 0 + 0 + 10$ $\quad \therefore \; h_L \neq 0$

ie $h_L = 15$ m

(b) $p_v = 7375$ Pa Table A.5 $\qquad V_3 = \frac{Q}{A_3} = \frac{40/3600}{(\frac{\pi}{4})D^2} = \frac{.0141}{D^2}$

Energy (1) – (3)

$\rho = 992$ kg/m³ Table A.2

assume $h_L = 15/2 = 7.5$ m

$$\frac{p_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{p_3}{\rho} + \frac{V_3^2}{2} + gz_3 + \frac{g}{2}h_L$$

$$\frac{101{,}350}{992} + 0 + 9.81(25) = \frac{7375}{992} + \frac{(.0141/D^2)^2}{2} + 0 + 9.81(7.5)$$

$D^4 = 3.75E{-}7$ m⁴ $\qquad D = .0248$ m ≈ 25 mm

$V_3 = 23$ m/s