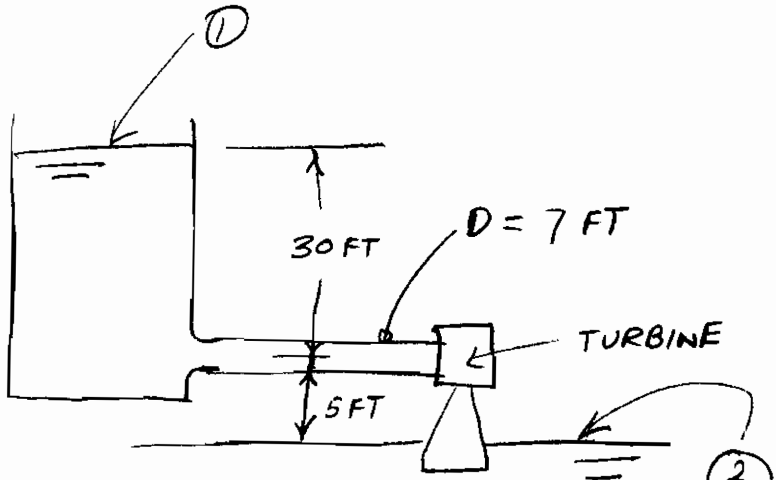
7.39



GIVEN: DISCHARGE OF 400 CFS THROUGH A TURBINE, Z

TURBINE EFFICIENCY IS 90%.

$$h_L = \frac{1.5\, V^2}{2g} \quad \text{IN PENSTOCK.}$$

FIND: POWER OUTPUT

SOLUTION: APPLY EXTENDED BERNOULLI FROM UPPER WATER SURFACE TO LOWER WATER SURFACE.

$$\cancel{\frac{p_1}{\gamma}}^{\,0} + z_1 + \alpha_1 \cancel{\frac{V_1^2}{2g}}^{\,0} = \cancel{\frac{p_2}{\gamma}}^{\,0} + \cancel{z_2}^{\,0} + \cancel{\alpha_2\frac{V_2^2}{2g}}^{\,0} + h_t + h_L$$

$$h_t = z_1 - h_L \qquad \dot{W}_t = \gamma Q\, h_t$$

$$h_t = z_1 - \frac{1.5 V^2}{2g} \qquad V = \frac{Q}{A} = \frac{400}{\frac{\pi}{4} 7^2} = 10.39 \frac{FT}{S}$$

$$h_t = 35\ FT - \frac{1.5\,(10.39)^2}{2\,(32.2)}\ FT = 32.5\ FT$$

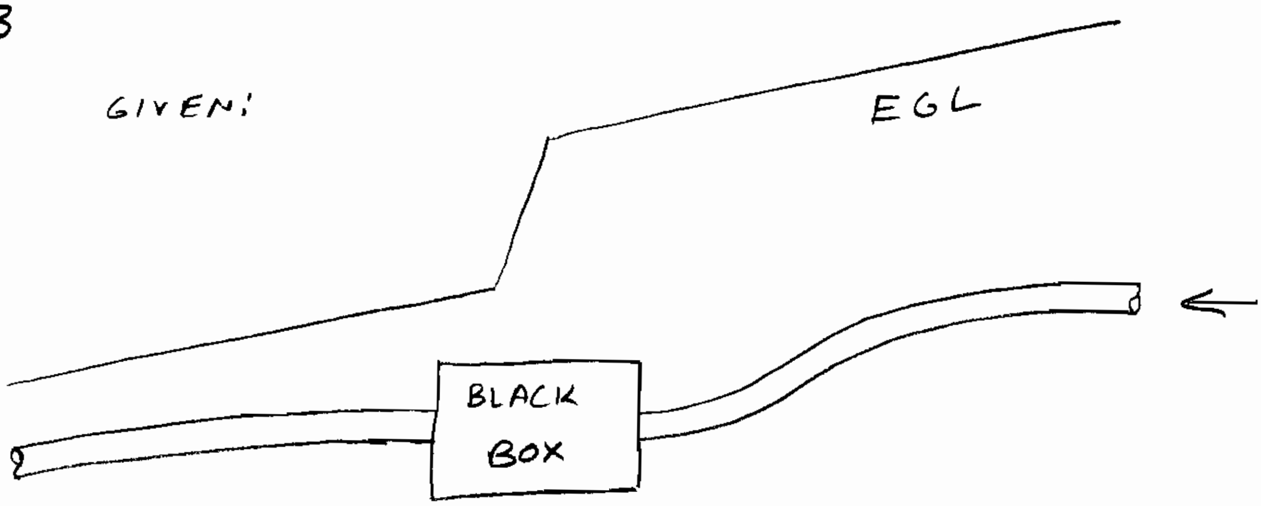
$$\dot{W}_t = \left(62.4 \frac{LBf}{FT^3}\right)\left(400 \frac{FT^3}{S}\right)\left(32.5\ FT\right) = 8.11 \times 10^5 \frac{FT\text{-}LBf}{S}$$

$$\dot{W}_t = 1474\ HP \qquad \text{POWER OUTPUT} = 0.9\, \dot{W}_t$$

$$\boxed{\text{POWER OUTPUT} = 1327\ HP}$$

7.63

GIVEN:



FIND: WHICH COULD BE IN BLACK BOX?

(a) PUMP

(b) PARTIALLY CLOSED VALVE

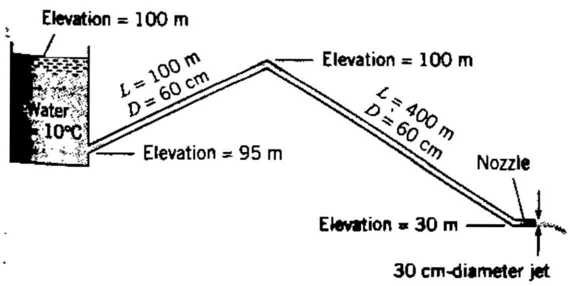
(c) ABRUPT EXPANSION

(d) TURBINE

SOLUTION: FLOW IS FROM RIGHT TO LEFT BECAUSE OF SLOPE OF EGL ABOVE INLET AND OUTLET PIPE. DROP IN EGL IN BLACK BOX COULD BE CAUSED BY (b) OR (d).

7.75

GIVEN: RESERVOIR DRAINING THROUGH PIPE AND JET AS SHOWN



$$h_L = 0.014 \left(\frac{L}{D}\right) \frac{V^2}{2g}$$

FIND: (a) DISCHARGE

(b) DRAW HGL & EGL

(c) LOCATION OF MAXIMUM PRESSURE

(d) " " MINIMUM "

(e) VALUE OF MAX. & MIN. PRESSURE

SOLUTION: PICK LOCATION ① AT THE FREE

(a) SURFACE OF THE RESERVOIR. PICK LOCATION ②

AT THE EXIT TO THE JET.

$$\cancelto{0}{\frac{p_1}{\gamma}} + \cancelto{100\,m}{z_1} + \alpha_1 \cancelto{0}{\frac{V_1^2}{2g}} = \cancelto{0}{\frac{p_2}{\gamma}} + \cancelto{30\,m}{z_2} + \alpha_2 \frac{V_2^2}{2g} + h_L$$

ASSUME FLOW IS TURBULENT $\rightarrow \alpha_2 = 1$

$$70\,m = \frac{V_2^2}{2g} + 0.014\left(\frac{L}{D}\right)\frac{V_P^2}{2g} \qquad L = 500\,m \;\&\; D = 0.6\,m$$

$V_2 \sim$ VELOCITY AT JET EXIT

$V_p \sim$ VELOCITY IN PIPE

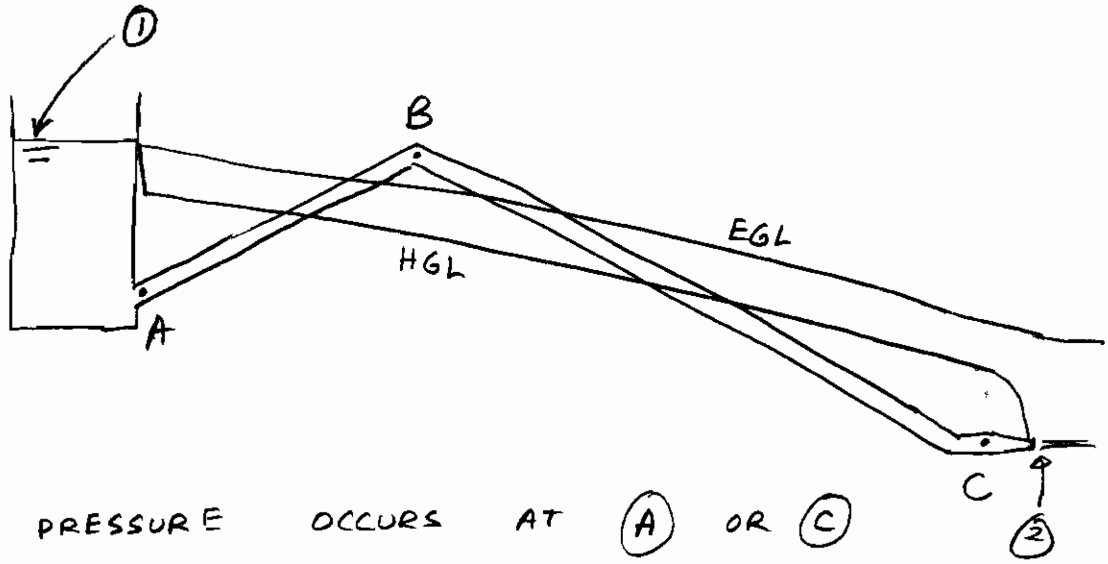
$$V_2 A_2 = V_p A_p \qquad V_2 = \frac{A_p}{A_2} V_p = \frac{D_p^2}{D_2^2} V_p = 4 V_p$$

$$70\,m = \frac{16 V_p^2}{2g} + 0.014\left(\frac{500}{.6}\right)\frac{V_p^2}{2g}$$

$$70\,m = \frac{V_p^2}{2g}(16 + 11.7) \qquad \boxed{V_p = 7.04 \frac{m}{s}}$$

$$Q = A_p V_p = \frac{\pi}{4} D_p^2 V_p \qquad \boxed{Q = 1.99 \frac{m^3}{s}}$$

(b)



(c) MAXIMUM PRESSURE OCCURS AT A OR C

(d) MINIMUM PRESSURE OCCURS AT B

(e)
$$\cancelto{0}{\frac{p_1}{\gamma}} + \cancelto{100\,\mathrm{M}}{z_1} + \cancelto{0}{\alpha_1 \frac{V_1^2}{2g}} = \frac{p_A}{\gamma} + \cancelto{95\,m}{z_A} + \frac{V_A^2}{2g} + \cancelto{\approx 0}{h_L}$$

$$\frac{p_A}{\gamma} = 5\,m - \frac{V_A^2}{2g} \qquad p_A = 9810\left[5 - \frac{7.04^2}{2(9.8)}\right]$$

$$p_A = 24.2 \text{ kPa gage}$$

$$\frac{p_c}{\gamma} + \cancelto{30\,\mathrm{M}}{z_c} + \alpha_c \frac{V_c^2}{2g} = \cancelto{0}{\frac{p_2}{\gamma}} + \cancelto{30\,\mathrm{M}}{z_2} + \alpha_2 \frac{V_2^2}{2g} + \cancelto{\approx 0}{h_L}$$

$$\frac{p_c}{\gamma} = \frac{1}{2g}\left(V_2^2 - V_c^2\right) = \frac{1}{2g}\left(16 V_c^2 - V_c^2\right)$$

$$p_c = \frac{1}{2}\rho\, 15 V_c^2 = \frac{1}{2}(1000)(15)(7.04)^2 = 372 \text{ kPa gage}$$

$$\boxed{p_{MAX} = p_c = 372 \text{ kPa gage}}$$

$$\cancelto{0}{\frac{p_1}{\gamma}} + \cancelto{100\,\mathrm{m}}{z_1} + \cancelto{0}{\alpha_1 \frac{V_1^2}{2g}} = \frac{p_B}{\gamma} + \cancelto{100\,\mathrm{M}}{z_B} + \alpha_B \frac{V_B^2}{2g} + h_L$$

$$\frac{p_B}{\gamma} = -\frac{V_B^2}{2g} - 0.014 \frac{L_{1B}}{D} \frac{V_B^2}{2g}$$

$$\frac{p_B}{\gamma} = -\frac{V_B^2}{2g}\left(1 + 0.014 \frac{100}{.6}\right) \qquad \boxed{p_B = -82.6 \text{ kPa gage}}$$