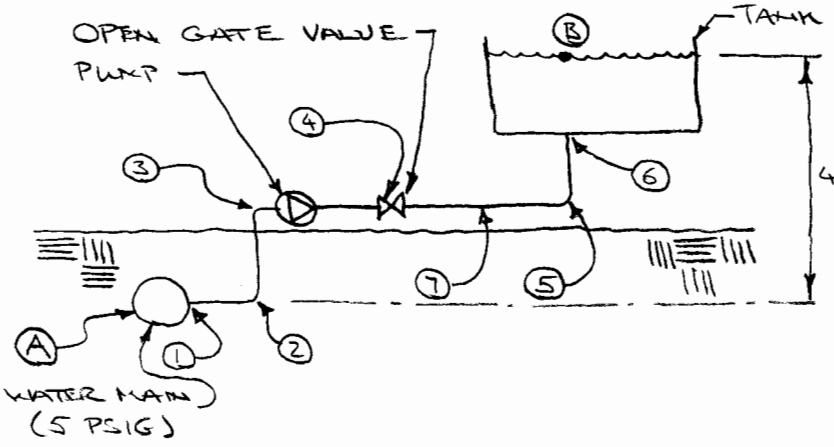
FLUIDS II - CLASS III (THE REAL WORLD WAY).

DESIGN A SYSTEM TO DELIVER 15 USGPM (US GALLONS/MINUTE) TO AN OPEN TANK 3000 FT. FROM A WATER MAIN. WATER MAIN PRESSURE IS 5 PSIG. THE PIPE MUST RISE 47 FT. TO ENTER THE TANK. MAKE IT WORK!

(1) PHYSICALLY LAYOUT THE SYSTEM.



PIPE LENGTH = 3000 FT.
PIPE SIZE = ?
PUMP SIZE = ?
PIPE MATERIAL = ?

FLOWRATE = 15 USGPM.

(2) SELECT PIPE MATERIAL: UNDERGROUND AND ABOVE GROUND SERVICE
CHOOSE: COPPER, TYPE K.

(3) SELECT PIPE SIZE:
RECOMMENDED FLOW VELOCITY: 2.0 TO 8.5 FT/S (T 6.3)
USE 4 FT/S

RECALL: $Q = UA$ SO $A = Q/U$

$Q = 15 \text{ USGPM} \times 1/449 \text{ USGPM}/(\text{ft}^3/\text{s}) = 3.34 \times 10^{-2} \text{ ft}^3/\text{s}$

SO $A = Q/U = 3.34 \times 10^{-2}/4 = 8.35 \times 10^{-3} \text{ ft}^2$

FROM APPENDIX H: SELECT 1¼" NOMINAL SIZE ($A = 8.454 \times 10^{-3} \text{ FT}^2$)

ACTUAL $U = Q/A = 3.34 \times 10^{-2}/8.454 \times 10^{-3} = 3.95 \text{ FT/S}$ O.K.

(4) DETERMINE LOSSES:

$$N_R = \frac{VD\rho}{\mu} = \frac{3.95(0.1037)(1.94)}{3.23 \times 10^{-5}}$$

$$= 2.46 \times 10^4$$

$$\frac{D}{\epsilon} = 0.1037/5 \times 10^{-6} = 20{,}740$$

$\therefore f = 0.024$

PIPE:
$A = 8.454 \times 10^{-3} \text{ FT}^2$
$ID = 0.1037 \text{ FT}$
$\epsilon = 5 \times 10^{-6} \text{ FT}$ (T 9.1)

FLUID:
$\gamma = 62.4 \text{ lb}/\text{ft}^3$
$\rho = 1.94 \text{ SLUGS}/\text{ft}^3$
$\mu = 3.23 \times 10^{-5} \text{ lb-s}/\text{ft}^2$

FITTING AND PIPE LOSSES:

$h_1 = K_L\left(\frac{v^2}{2g}\right) = 0.5\left(\frac{3.95^2}{2\times 32.2}\right) =$ 0.121

$h_2 = f\left(\frac{L_e}{D}\right)\left(\frac{v^2}{2g}\right) = 0.024(30)\left(\frac{3.95^2}{2\times 32.2}\right) =$ 0.174 (for 90° standard elbow Table 10.4)

$h_3 = h_2 =$ 0.174

$h_4 = f\left(\frac{L_e}{D}\right)\left(\frac{v^2}{2g}\right) = (0.024)(13)\left(\frac{3.95^2}{2\times 32.2}\right) =$ 0.076

$h_5 = h_2 =$ 0.174

$h_6 = K_L\left(\frac{v^2}{2g}\right) = 1.0\left(\frac{3.95^2}{2\times 32.2}\right) =$ 0.242 (Exit loss, Fig 10.3)

$h_7 = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) = (0.024)\left(\frac{3000}{0.1039}\right)\left(\frac{3.95^2}{2\times 32.2}\right) =$ 168.2

$h_L = \Sigma h_L =$ ⟶ 169.2 FT.

⑤ DETERMINE h_A:

RECALL $\frac{P_A - P_B}{\gamma} + (z_A - z_B) + \frac{v_A^2 - v_B^2}{2g} + h_A - h_R - h_L = 0$

LIMITS: $P_A = 5$ PSIG $= 720$ PSF, $z_A = 0$, $v_A = 0$

$P_B = 0$ PSF, $z_B = 47$ FT, $v_B = 0$

$h_A = ?$, $h_R = 0$, $h_L = 169.2$ FT.

SO $h_A = -\left[\frac{(P_A - P_B)}{\gamma} + (z_A - z_B) + \frac{(v_A^2 - v_B^2)}{2g} - h_R - h_L\right]$

$= -\left[\frac{(720 - 0)}{62.4} + (0 - 47) - 169.2\right]$

$= 204.7$ FT $(= 62.4\ m)$ ALSO $\dot{Q} = 15$ USGPM $(= 0.946\ \frac{L}{s})$

⑥ DETERMINE PUMP POWER:

RECALL: $P_A = h_A \gamma Q$

$= 204.7(62.4)(3.34\times 10^{-2})$

$= 426.6$ ft-lb/s

$= 0.776$ HP

AT 50% EFFICIENCY THE ACTUAL PUMP REQUIRED IS:

HP OF PUMP $= P_A/\eta = 0.776/0.5 = 1.56$ HP

CHOOSE A 2 HP PUMP, MOTOR