40.10 A hotel with 400 units requires a maximum cold water supply of $5gpm$ per unit with a diversity factor of 60%. The supply line is $5000ft$ long and made of $8in$ standard weight steel with a roughness coefficient of $C = 130$. The minimum required pressure for all fixtures in the hotel is $80psig$. The start of the supply line is $100ft$ above the delivery end at the hotel. What is the minimum pressure required at the start of the line?

A. $93psig$

B. $108psig$

C. $128psig$

D. $180psig$

Start by writing the Bernoulli Equation:

$$\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + h_f$$

Neglect velocity and isolate the unknown P_1.

$$\frac{P_1}{\gamma} = \frac{P_2}{\gamma} + (z_2 - z_1) + h_f$$

The design volume flow rate, Q, depends on the required volume per unit, the number of units, and the diversity:

$$Q = (400\,units)\left(5\frac{gpm}{unit}\right)(.6) = 1200gpm$$

Using the steel pipe friction tables look up the friction loss for $1200gpm$ through a nominal 8 inch pipe:

$$h_d\,loss = 4.2ft\,per\,100ft$$

The tables assume a roughness factor of $C = 100$, but this problem has given a roughness factor of $C = 130$, which implies there is less friction loss. A table of surface roughness factors is given immediately before the steel pipe friction tables and provides correction factors for various values of the surface roughness, C. Select the correction factor for $C = 130$ and find the actual losses.

$$h_f = \left(\frac{4.2ft}{100ft}\right)(5000ft)(.62) = 130.2ft$$

Use the rule of thumb conversion factor for water $2.31\frac{ft}{psi}$ for convenience converting between pressure units and feet of head. Note that $\Delta z = z_2 - z_1$ has a negative value since $z_1 > z_2$ due to the start of the supply line being higher than the delivery point. Solve for P_1.

$$\frac{P_1}{\gamma} = \frac{P_2}{\gamma} + (z_2 - z_1) + h_f$$

$$\frac{P_1}{\gamma} = (80psi)\left(2.31\frac{ft}{psi}\right) - 100ft + 130.2ft = 215ft$$

$$P_1 = \frac{215ft}{2.31\frac{ft}{psi}} = 93psig$$

Since the required fixture pressure and answer choices are given in psig, it is not necessary to account for atmospheric pressure at any point in the problem.

Answer A

40.11 What is the friction loss per hundred feet for $800gpm$ of $80°F$ water flowing through an $8in$ nominal schedule 40 steel pipe?

A. $1ft$

B. $2ft$

C. $3ft$

D. $4ft$

Start with the Darcy Equation:

$$h_f = \frac{fLv^2}{2gD}$$

Using the Steel Pipe Friction Tables, look up the diameter for a nominal 8 inch pipe and the velocity of $800gpm$ through a pipe of that size:

$$D = 7.981in\left(\frac{1ft}{12in}\right) = 0.6651ft$$

$$v = 5.13\frac{ft}{s}$$

The friction factor is a function of the Reynolds Number, Re, and the relative roughness, $\frac{\epsilon}{D}$. Look up the Properties of Water table to find the kinematic viscosity at $80°F$.

$$Re = \frac{vD}{\nu} = \frac{\left(5.13\frac{ft}{s}\right)(0.6651ft)}{0.93\times10^{-5}\frac{ft^2}{s}} \approx 370,000$$

The roughness factor, ϵ, is assumed to have an average value of $0.0002ft$ for Schedule 40 steel pipe aka commercial steel.

$$\frac{\epsilon}{D} = \frac{0.0002ft}{0.6651ft} \approx 0.0003$$

Using the Moody Diagram:

$$f = f\left(Re, \frac{\epsilon}{D}\right) \approx 0.0165$$