

33.5 50gpm of cold water at 60°F enters a 100ft tall building via 3in schedule 40 steel supply piping. Street pressure prior to the service entrance to the building is 85psig. The equivalent length of piping on the longest run to the top floor is 500feet. What pressure is available to fixtures on the top floor?

- A. 40psig
- B. 42psig
- C. 45psig
- D. 55psig

Start by writing the **Bernoulli Equation**, where P is static pressure, v is velocity, z is height, and h_f is friction loss. Neglecting the velocity term which makes a negligible contribution in many problems involving comparatively large static pressures and heights, and rearrange to solve for the unknown P_2 on the top floor of the building.

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

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

Note the specific weight, $\gamma = \rho g$; however, at the end of the problem, save time by using the rule of thumb conversion factor for water.

The street pressure P_1 is given and the Δz is known based on the height of the building. The main effort of the problem is finding the losses, h_f , using the **Darcy-Weisbach Equation**.

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

Using the **Steel Pipe Friction Tables**, the diameter of a nominal 3 inch pipe and the velocity of 50gpm through the pipe can be gathered:

$$D = \frac{3.068in}{12\frac{in}{ft}} = 0.2557ft$$

$$@50gpm : V = 2.17\frac{ft}{sec}$$

Calculate the **Reynolds Number**. Lookup the **Kinematic Viscosity** of water @ $T = 60^\circ F$ by searching for **Properties of Water**.

$$Re = \frac{vD}{\nu} = \frac{\left(2.17\frac{ft}{sec}\right) (.2557ft)}{\left(1.217 \times 10^{-5}\frac{ft^2}{sec}\right)} = 45,600$$

Find the Relative Roughness. Values for ϵ for standard weight steel are shown on the **Moody Diagram**. It is fine to round off the diameter since the Moody Diagram provides limited precision.

$$\frac{\epsilon}{D} = \frac{.0002ft}{.25ft} = .0008$$

Read the friction factor from the Moody Diagram.

$$f = f\left(Re, \frac{\epsilon}{D}\right) \approx .023$$

Determine the pressure losses. Be sure to use the equivalent length for L .

$$h_f = \frac{fLv^2}{2gD} = \frac{(.023)(500ft)\left(2.17\frac{ft}{sec}\right)^2}{2(.2557ft)\left(32.2\frac{ft}{sec^2}\right)} = 3.3ft$$

Determine P_2 . 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 $\Delta z = z_1 - z_2$ as written has a negative value since $z_2 > z_1$ due to being higher in the building.

$$\frac{P_2}{\gamma} = \frac{P_1}{\gamma} + (z_1 - z_2) - h_f = (85psi)\left(2.31\frac{ft}{psi}\right) + (0ft - 100ft) - 3.3ft = 93.05ft$$

$$\frac{P_2}{\gamma} = 93.05ft \rightarrow P_2 = \frac{93.05ft}{2.31\frac{ft}{psi}} = 40.3psig$$

Note the street pressure was given in psig and the answer choices are in psig, and since it is a continuous system there is no need to convert to psia at any point.

Answer A