

33.24 40gpm of water is supplied to a parallel piping system with two branches of 2in diameter standard weight steel and with equivalent lengths of 80ft and 120ft for branches A and B, respectively. The flow recombines at a tee after flowing through the two branches. What is the velocity in branch A?

- A. 1.7fps
- B. 2.1fps
- C. 3.1fps
- D. 3.8fps

For parallel piping systems, the friction loss through all branches is equal. Set the friction loss through branches A and B equal to each other, and write the **Darcy-Weisbach Equation** for both sides.

$$h_{f,A} = h_{f,B}$$

$$\frac{fL_A v_A^2}{2Dg} = \frac{fL_B v_B^2}{2Dg}$$

The diameter is the same for each branch and the friction loss may also be assumed to be the same due to the similarity in the material and pipe size. A small difference in velocity is unlikely to drive a meaningful difference in the friction factor, f . The constants 2 and g also cancel out. Therefore an expression relating the length of the branches and the velocity can be determined.

$$L_A v_A^2 = L_B v_B^2$$

Rearrange to express a ratio of the velocities. Since the lengths are known, compute the value of the ratio.

$$\frac{L_A}{L_B} = \left(\frac{v_B}{v_A}\right)^2$$

$$\frac{v_B}{v_A} = \sqrt{\frac{L_A}{L_B}} = \sqrt{\frac{80ft}{120ft}} = 0.816$$

Since the branches have the same diameter, the volume flow rates are directly proportional to the velocities.

$$Q_A = v_A A$$

$$Q_B = v_B A$$

$$\frac{Q_B}{Q_A} = \frac{v_B A}{v_A A} = \frac{v_B}{v_A} = 0.816$$

The sum of volume flow rates through the two branches must add to the total volume flow rate, $40gpm$.

$$Q_A + Q_B = 40gpm$$

Use substitution to simultaneously solve the two equations with two unknowns, with primary interest in the volume flow rate through branch A.

$$Q_B = 40 - Q_A$$

$$\frac{40 - Q_A}{Q_A} = 0.816$$

$$\frac{40}{Q_A} - 1 = 0.816$$

$$\frac{40}{Q_A} = 1.816$$

$$Q_A = \frac{40}{1.816} = 22gpm$$

Lastly, use the **Schedule 40 Steel Pipe** table to obtain the area for a nominal $2in$ pipe and determine the velocity through branch A. Convert units to $\frac{ft}{s}$ (fps) for the final answer.

$$v_A = \frac{Q_A}{A} = \frac{\left(22 \frac{gal}{min}\right) \left(\frac{1ft^3}{7.48gal}\right) \left(\frac{1min}{60s}\right)}{\left(\frac{3.354in^2}{144 \frac{in^2}{ft^2}}\right)} = 2.1 \frac{ft}{s}$$

Answer B