**33.45** **Four $2in$ fuel oil supply lines with equal flow feed into a common $4in$ main supply line. What is the ratio of the pressure drop per unit length in the main line as compared with the supply lines. Assume all piping is standard weight steel, there is no change in elevation, and the friction factors are the same in all lines.**

A. 0.14

B. 0.57

C. 1.6

D. 2.2

The ratio of the pressure drop for the main as compared to the feeders is equal to the ratio of the head loss because $\Delta p = \rho g h_f$, and the density can be assumed to be constant and gravity is constant. Write the Darcy-Weisbach Equation for both the numerator and denominator.

$$\frac{\Delta p_{main}}{\Delta p_{feeder}} = \frac{h_{f,main}}{h_{f,feeder}} = \frac{\left(\frac{fLv_m^2}{2D_m g}\right)}{\left(\frac{fLv_f^2}{2D_f g}\right)}$$

Cancel the friction factor, $f$, since it is the same for all lines. Cancel the length, $L$, since the problem is interested in the losses per unit length. Cancel 2 and $g$ as they are both constants. Simplify the expression.

$$\frac{\Delta p_{main}}{\Delta p_{feeder}} = \left(\frac{v_m}{v_f}\right)^2 \frac{D_f}{D_m}$$

Use the relation $Q = vA$ to write expressions for the velocities as a function of their respective volume flow rates and diameters. Since there are 4 feeders flowing into the main, the flow rate of the main is four times the flow rate of any individual feeder.

$$Q_m = 4Q_f$$

$$v_m = \frac{Q_m}{A_m} = \frac{4Q_f}{\frac{\pi}{4}D_m^2}$$

$$v_f = \frac{Q_f}{A_f} = \frac{Q_f}{\frac{\pi}{4}D_f^2}$$

Substitute the above experessions into the previous equation and simplify.

$$\frac{\Delta p_{main}}{\Delta p_{feeder}} = \left(\frac{\left(\frac{4Q_f}{\frac{\pi}{4}D_m^2}\right)}{\left(\frac{Q_f}{\frac{\pi}{4}D_f^2}\right)}\right)^2 \frac{D_f}{D_m} = 16\left(\frac{D_f}{D_m}\right)^5$$

Use the Schedule 40 Steel Pipe table to look up the exact diameters for $2in$ and $4in$ nominal pipe sizes. Substitute and solve.

$$\frac{\Delta p_{main}}{\Delta p_{feeder}} = 16\left(\frac{2.067in}{4.026in}\right)^5 = 0.57$$

**Answer B**