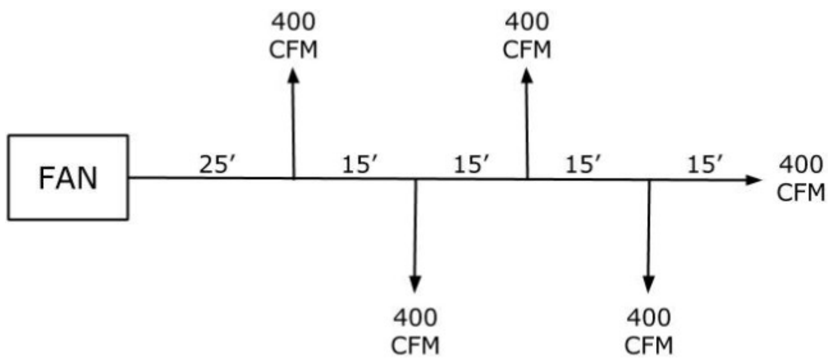
43.15 The supply fan and duct distribution for a restaurant are as shown. The velocity is not to exceed $1800 fpm$. Each of the five $400 cfm$ outlets requires a minimum terminal pressure of $0.2 in\, wg$. How much static pressure must the fan be capable of supplying? Assume equal friction losses throughout the main run.

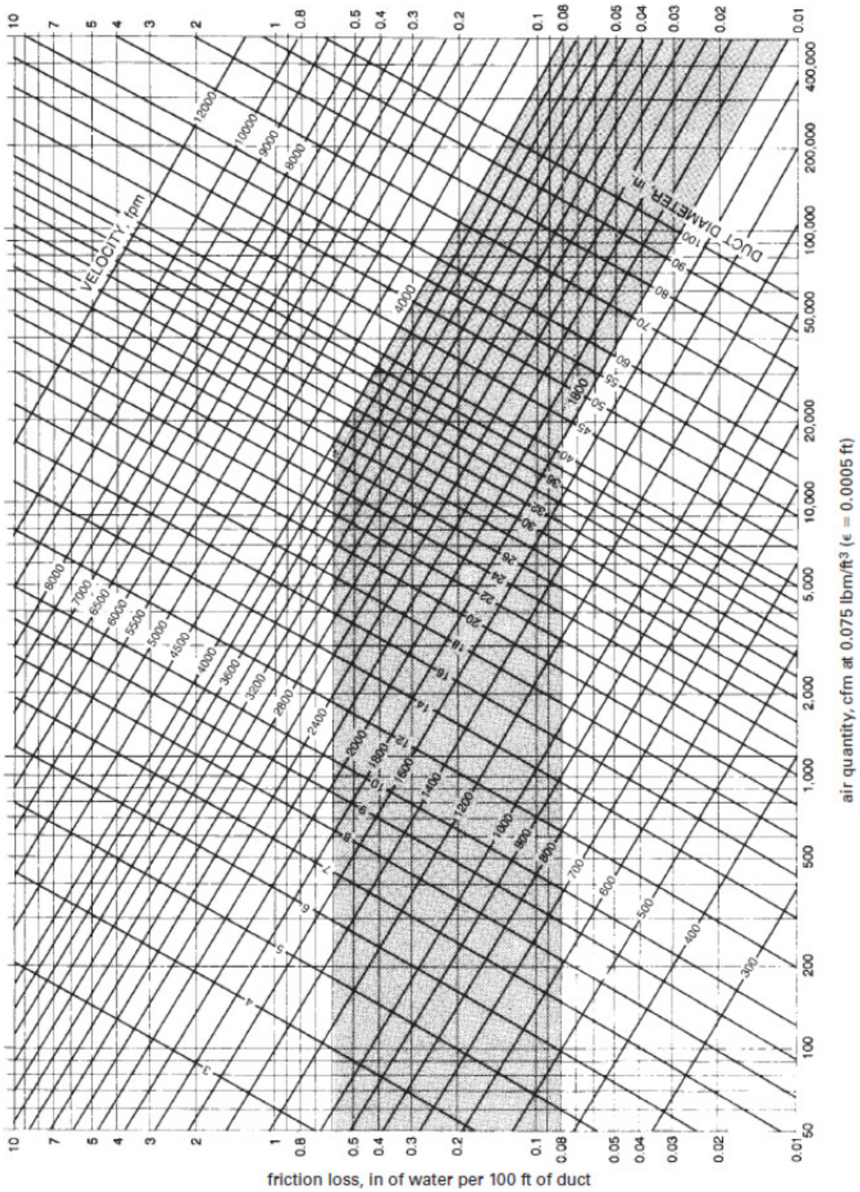


A. $0.18 in\, wg$

B. $0.23 in\, wg$

C. $0.34 in\, wg$

D. $0.40 in\, wg$



The diameter has not been given. Size the main duct based on the maximum velocity and total cfm:

$$Q = 5\,(400cfm) = 2000cfm$$

$$V_{max} = 1800\frac{ft}{min}$$

$$Q = VA \rightarrow A = \frac{Q}{V}$$

$$A = \frac{2000\frac{ft^3}{min}}{1800\frac{ft}{min}} = 1.11ft^2 = \frac{\pi}{4}D^2$$

$$D = 1.19ft = 14.27in$$

Round the duct diameter up because rounding down will cause the duct to be undersized and the maximum velocity will be exceeded. By slightly oversizing, the velocity will remain within the satisfactory range. Choose $D = 15in$. Calculate the velocity:

$$V = \frac{Q}{A} = \frac{2000\frac{ft^3}{min}}{\frac{\pi}{4}\left(\frac{15}{12}ft\right)^2} = 1630\frac{ft}{min} < 1800\frac{ft}{min}$$

Use any 2 of the 3 parameters (diameter, velocity, cfm) to look up the friction loss using the chart provided. Multiply by the length of the longest run in the system:

$$\Delta P_{loss} = .24in\,wg/100ft$$

$$L = 25ft + 4\,(15ft) = 85ft$$

$$\Delta P_{ductwork} = \left(\frac{.24in\,wg}{100ft}\right)(85ft) = .2in\,wg$$

It is also necessary to include the required terminal pressure at the outlet, since this pressure must also be supplied by the fan.

$$\Delta P_{total} = .2in\,wg + .2in\,wg = .4in\,wg$$

The total pressure is the sum of the static pressure and velocity pressure. Solve for the static pressure by subtracting the velocity pressure and solve:

$$p_t = p_s + p_v \rightarrow p_s = p_t - p_v$$

$$p_v = \left(\frac{V}{4005}\right)^2$$

$$p_s = p_t - \left(\frac{V}{4005}\right)^2 = .4in\,wg - \left(\frac{1630}{4005}\right)^2 = .23in\,wg$$

Answer B