31.11 **$1\frac{lb_m}{min}$ of pure oxygen at $14.7psia$ and $68°F$ will be distributed on an aircraft during an emergency through a $3in$ diameter main duct. What is the velocity?**

A. $30\frac{ft}{min}$

B. $250\frac{ft}{min}$

C. $270\frac{ft}{min}$

D. $310\frac{ft}{min}$

Mass flow rate and volume flow rate are related by the density.

$$\dot{m} = \rho Q$$

Volume flow rate may be represented as velocity times area.

$$Q = VA$$

Substitute, and solve for velocity.

$$\dot{m} = \rho VA \rightarrow V = \frac{\dot{m}}{\rho A}$$

The mass flow rate is given. Find the area of the duct.

$$A = \frac{\pi}{4}D^2 = \frac{\pi}{4}\left(\frac{3in}{12\frac{in}{ft}}\right)^2 = 0.049ft^2$$

Treat oxygen as an ideal gas. Density can be found by adapting the Ideal Gas law. The Gas Constant for oxygen must be determined from the Universal Gas Constant and the molecular weight. Be sure to use absolute temperaute i.e. Rankine rather than degrees Farenheit.

$$PV = mRT \rightarrow P = \rho RT \rightarrow \rho = \frac{P}{RT}$$

$$R_{O_2} = \frac{\bar{R}}{M_{O_2}} = \frac{1545\frac{ft \cdot lb_f}{lb_{mol} \cdot {}^\circ R}}{32\frac{lb_m}{lb_{mol}}} = 48.3\frac{ft \cdot lb_f}{lb_m \cdot {}^\circ R}$$

$$\rho = \frac{P}{RT} = \frac{\left(14.7\frac{lb_f}{in^2}\right)\left(\frac{144in^2}{1ft^2}\right)}{\left(48.3\frac{ft \cdot lb_f}{lb_m \cdot {}^\circ R}\right)(528^\circ R)} = 0.083\frac{lb_m}{ft^3}$$

Calculate the velocity.

$$V = \frac{\dot{m}}{\rho A} = \frac{\left(1\frac{lb_m}{min}\right)}{\left(0.083\frac{lb_m}{ft^3}\right)(0.049ft^2)} = 246\frac{ft}{min}$$

Answer B