33.36 $20,000\frac{lb}{hr}$ **of steam at** $500°F$ **and** $500psia$ **flows in a** $4in$ **nominal steel pipe. The friction factor is** 0.022**. What is the pressure drop per foot of pipe?**

A. $0.0004psi$

B. $0.03psi$

C. $0.3psi$

D. $4psi$

The pressure drop can be determined in ft using the Darcy-Weisbach Equation, then converted to psi at the end.

$$h_f = \frac{fLV^2}{2Dg}$$

Use the Schedule 40 Steel Pipe table to look up the diameter and area of the pipe.

$$D = 4.026in$$

$$A = 12.724in^2$$

Use the Properties of Superheated Steam to look up the specific volume of steam at $500°F$ and $500psia$.

$$v = 0.996\frac{ft^3}{lb_m}$$

To find the velocity, recall the relations below and combine. To distinguish velocity from specific volume, this solution uses uppercase V for the former and lowercase v for the latter.

$$Q = VA$$

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

$$v = \frac{1}{\rho}$$

$$V = \frac{Q}{A} = \frac{\dot{m}}{\rho A} = \frac{\dot{m}v}{A}$$

$$V = \frac{\left(20,000\frac{lb_m}{hr}\right)\left(\frac{1hr}{3600s}\right)\left(0.996\frac{ft^3}{lb_m}\right)}{(12.724in^2)\left(\frac{1ft^2}{144in^2}\right)} = 62.6\frac{ft}{s}$$

Determine h_f.

$$h_f = \frac{(0.022)\,(1ft)\left(62.6\frac{ft}{s}\right)^2}{2\left(\frac{4.026in}{12\frac{in}{ft}}\right)\left(32.2\frac{ft}{s^2}\right)} = 3.99ft$$

Calculate the Pressure Drop which is corresponding psi for the losses in ft.

$$\Delta p = \frac{\rho g h_f}{g_c} = \frac{h_f g}{v g_c}$$

$$\Delta p = \frac{(3.99ft)\left(32.2\frac{ft}{s^2}\right)}{\left(0.996\frac{ft^3}{lb_m}\right)\left(32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}\right)} \frac{1ft^2}{144in^2} = 0.028\frac{lb_f}{in^2}$$

Answer B