

Start by checking the **Steel Pipe Friction Tables**. The largest diameter provided is $12in$ and the maximum volume flow rate is $4000gpm$. Eliminate choice A.

Since there is no additional information aside from the flow rate, use a rule of thumb. One handy option is to divide gpm by 20 and take the square root. This is only for getting a ballpark answer.

$$D_{[in]} \approx \sqrt{\frac{Q_{[gpm]}}{20}} = \sqrt{\frac{8000}{20}} = 20in$$

Eliminate choice D as $32in$ is likely excessive. Since $20in$ is only slightly larger than $18in$, answer B is still worth considering.

Another approach is to assume a typical maximum velocity, such as $5\frac{ft}{s}$, and solve for the required area.

$$Q = vA$$

$$A = \frac{Q}{v} = \frac{\left(8000\frac{gal}{min}\right)\left(\frac{1ft^3}{7.48gal}\right)\left(\frac{1min}{60s}\right)}{5\frac{ft}{s}} = 3.56ft^2$$

Solve for the diameter.

$$A = \frac{\pi}{4}D^2$$

$$D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(3.56ft^2)}{\pi}} = 2.13ft\left(\frac{12in}{1ft}\right) = 25.6in$$

Since the diameter is only slightly larger than $24in$, and the first rule of thumb gave a 20% smaller answer, choose $24in$.

Answer C

47.54 A pressurized tank contains air at $300psia$. What is the Mach number of air exiting to the atmosphere through a hole in the tank?

- A. 0.8
- B. 2.6
- C. 4.2
- D. 5.5

Determine the ratio of the pressure downstream of the opening to the pressure inside the tank.

$$\frac{P}{P_0} = \frac{14.7psia}{300psia} = 0.049$$

Use the **One-Dimensional Isentropic Compressible-Flow Functions** table to look up the pressure ratio and obtain the corresponding **Mach Number**, M .

$$M \approx 2.6$$

Alternatively, use the equation from **Isentropic Flow Relationships**. Solve for M . Assume the ratio of specific heats $k = 1.4$.

$$\frac{P_0}{P} = \left(1 + \frac{k-1}{2}M^2\right)^{\frac{k}{k-1}}$$

$$M = \sqrt{\left(\frac{2}{k-1}\right) \left[\left(\frac{P_0}{P}\right)^{\frac{k-1}{k}} - 1\right]}$$

$$M = \sqrt{\left(\frac{2}{1.4-1}\right) \left[\left(\frac{300psia}{14.7psia}\right)^{\frac{1.4-1}{1.4}} - 1\right]} = 2.61$$

Answer B

47.55 A pump requires 120hp to transport 1400gpm. What percent reduction in power will be realized when the flow rate is reduced to 800gpm?

- A. 19%
- B. 33%
- C. 67%
- D. 81%

Reference the **Pump Affinity Laws** and use the equation for horsepower as a function of speed. Speed and volume flow rate are linearly proportional, therefore the ratio of the volume flow rates may be substituted for the ratio of the speeds.

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

$$bhp_2 = bhp_1 \left(\frac{N_2}{N_1}\right)^3$$

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Consider the original operating conditions as State 1, and the new conditions as State 2. Substitute and solve for the new power.

$$bhp_2 = (120hp) \left(\frac{800gpm}{1400gpm}\right)^3 = 22.4hp$$