

**46.59** A fan rated for  $15bhp$  is controlled by a variable frequency drive and runs at  $900rpm$  which is  $50\%$  of its maximum speed, supplying  $20,000cfm$  of air against a system pressure of  $1.5in\ wg$ . The existing filters are replaced with new high efficiency filters increasing the pressure drop by  $0.75in\ wg$ . What is the required fan speed following this upgrade?

- A.  $1100rpm$
- B.  $1350rpm$
- C.  $2030rpm$
- D.  $3040rpm$

Consider the original operating conditions as State 1 and the final operating conditions as State 2. Use the **Fan Affinity Laws** to find the new speed,  $N_2$ . Pressure changes with the *square* of the change in speed. Therefore, speed changes with the *square root* of the change in pressure. Select equation '1b' and cross out the diameter and density ratios which are not changing and may be assumed to equal 1.

$$P_1 = P_2 \left( \frac{N_1}{N_2} \right)^2$$

$$N_2 = N_1 \sqrt{\frac{P_2}{P_1}} = (900rpm) \sqrt{\frac{2.25in\ wg}{1.5in\ wg}} = 1102rpm$$

**Answer A**

**46.60** An atypical hydronic system permits the velocity of water to reach a maximum of  $12\frac{ft}{s}$  when required. What is the smallest nominal schedule 40 steel pipe size that should be selected for a flow rate of  $50gpm$ ?

- A.  $1in$
- B.  $1.25in$
- C.  $1.5in$
- D.  $2in$

Use the relation  $Q = vA$  to specify the required area. Express area as  $A = \frac{\pi}{4}D^2$  and solve for the minimum diameter.

$$A = \frac{Q}{v}$$

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

$$\frac{\pi}{4} D^2 = \frac{Q}{v}$$

$$D = \sqrt{\frac{4Q}{\pi v}} = \sqrt{\frac{4 \left( 50 \frac{\text{gal}}{\text{min}} \right) \left( \frac{1 \text{ft}^3}{7.48 \text{gal}} \right) \left( \frac{1 \text{min}}{60 \text{s}} \right)}{\pi \left( 12 \frac{\text{ft}}{\text{s}} \right)}} = 0.109 \text{ft} \left( \frac{12 \text{in}}{1 \text{ft}} \right) = 1.30 \text{in}$$

Refer to the **Schedule 40 Steel Pipe** table. The inside diameter of a 1.25in nominal pipe size is physically 1.38in. There is no need to choose a larger size.

**Answer B**

**46.61** 1200gpm of water flows through a 50ft length of pipe with a 8in inside diameter and a friction factor of 0.02. What is the pressure drop?

- A. 0.2psi
- B. 0.6psi
- C. 1.4psi
- D. 5.9psi

Determine the velocity of water flowing in the pipe. The **Steel Pipe Friction Tables** provide a reasonable approximation, however the problem does not state 'nominal' or 'standard weight' or 'schedule 40.' Therefore, it is recommended to calculate the values manually.

$$Q = vA$$

$$v = \frac{Q}{A} = \frac{\left( 1200 \frac{\text{gal}}{\text{min}} \right) \left( \frac{1 \text{ft}^3}{7.48 \text{gal}} \right) \left( \frac{1 \text{min}}{60 \text{s}} \right)}{\frac{\pi}{4} \left( \frac{8 \text{in}}{12 \frac{\text{in}}{\text{ft}}} \right)^2} = 7.66 \frac{\text{ft}}{\text{s}}$$

Use the **Darcy-Weisbach Equation** to find the head loss in ft. Then use the rule of thumb conversion factor for water to convert the units to psi for the pressure drop.

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

$$h_f = \frac{(0.02) (50 \text{ft}) \left( 7.66 \frac{\text{ft}}{\text{s}} \right)^2}{2 \left( \frac{8 \text{in}}{12 \frac{\text{in}}{\text{ft}}} \right) \left( 32.2 \frac{\text{ft}}{\text{s}^2} \right)} = 1.37 \text{ft}$$

$$\Delta P = \frac{1.37 \text{ft}}{2.31 \frac{\text{ft}}{\text{psi}}} = 0.59 \text{psi}$$

**Answer B**