

**43.16** A 70% efficient fan is driven by a 90% efficient motor at standard conditions. The motor is rated for 7.5hp. The fan develops a static pressure of 2.8in wg. The fan is then used in a heating application delivering 110°F air. What volume flow rate of air is supplied?

- A. 10,700cfm
- B. 11,400cfm
- C. 11,900cfm
- D. 12,600cfm

The motor efficiency is extra information because motors are rated based on their brake horsepower (*bhp*) and this problem is not concerned with the electrical power input to the motor. Apply the fan efficiency to the *bhp* to determine the fan power, or air horsepower, then solve for the volume flow rate at standard conditions:

$$AHP = (.7) (7.5hp) = 5.25hp$$

$$AHP = P_s = \frac{Q_s \Delta p_s}{6356}$$

$$Q_s = \frac{(6356)(5.25)}{2.8} = 11,918cfm$$

For an application where the air temperature is higher than standard conditions, the air density will be lower therefore the volume flow rate should be higher.

$$T_2 > T_1$$

$$Q_2 > Q_1$$

The increase in *cfm* will be linear with the change in the *absolute* temperature. Set up a proportion:

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

$$Q_2 = Q_1 \left( \frac{T_2}{T_1} \right) = 11,918cfm \left( \frac{110^\circ F + 460^\circ}{77^\circ F + 460^\circ} \right) = 12,650cfm$$

**Answer D**

**43.17** A 20,000  $ft^2$  factory uses LED lighting with a power density of  $0.7W/ft^2$  for the LED strips plus 15% for drivers. The space contains eight 93% efficient 7.5hp motors operating at an average of 70% of their rated capacity. The machinery driven by the motors is located within the conditioned space. There are 120 factory employees performing light machine work. What is the total internal heat gain?

- A.  $180,000 \frac{Btu}{hr}$
- B.  $185,000 \frac{Btu}{hr}$
- C.  $280,000 \frac{Btu}{hr}$
- D.  $330,000 \frac{Btu}{hr}$

Calculate the heat gain from the lighting. Convert units to  $\frac{Btu}{hr}$ :

$$\dot{Q}_{lighting} = (20000ft^2) \left( .7 \frac{W}{ft^2} \right) (1.15) \left( 3.412 \frac{\frac{Btu}{hr}}{W} \right) = 54,933 \frac{Btu}{hr}$$

Calculate the heat gain for the motors. Note the entire electrical load (operating at 70% of its capacity) counts as heat gain since the equipment powered is *within* the conditioned space, regardless of whether the power turns into mechanical work or heat loss. The motor efficiency need not be accounted for. Convert units to  $\frac{Btu}{hr}$ :

$$\dot{Q}_{motors} = (8) (7.5hp) (.7) \left( 745.7 \frac{W}{hp} \right) \left( 3.412 \frac{\frac{Btu}{hr}}{W} \right) = 106,862 \frac{Btu}{hr}$$

Look up **Human Cooling Loads** in the Reference Handbook and find the value for **light machine work**. Calculate the heat gain for the workers:

$$\dot{Q}_{people} = (120people) \left( 1000 \frac{\frac{Btu}{hr}}{person} \right) = 120,000 \frac{Btu}{hr}$$

Calculate the total heat gain:

$$\begin{aligned} \dot{Q}_{total} &= \dot{Q}_{lighting} + \dot{Q}_{motors} + \dot{Q}_{people} \\ \dot{Q}_{total} &= 54,933 \frac{Btu}{hr} + 106,862 \frac{Btu}{hr} + 120,000 \frac{Btu}{hr} = 281,795 \frac{Btu}{hr} \end{aligned}$$

**Answer C**