FAN LAWS

1. Effect of Blower Speed on Flow, Pressure and Power Consumption

a. Flow vs. Speed: The flow rate (V) changes in direct ratio to the speed (S)

$$\frac{V_2}{V_1} = \frac{S_2}{S_1}$$

Example: A blower operating at 1750 rpm (S_1) delivers 1000 cfm (V_1). How many cfm (V_2) will it deliver if speed is increased to 3500 rpm (S_2)?

$$V_2 = V_1 \times \frac{S_2}{S_1} = 1000 \times \frac{3500}{1750} = 2000 \text{ cfm}$$

b. Pressure vs. Speed: The pressure (P) changes as the square of the speed ratio (S)

$$\frac{P_2}{P_1} = \left(\frac{S_2}{S_1}\right)^2$$

Example: A blower operating at 1750 rpm (S_1) develops 1 psig (P_1) pressure. If speed is doubled to 3500 rpm (S_2), what is the new pressure (P_2)?

$$P_2 = P_1 \times \left(\frac{S_2}{S_1}\right)^2 = 1 \times \left(\frac{3500}{1750}\right)^2$$

$$= 1 \times (2)^2 = 1 \times 4 = 4 \text{ psig}$$

c. Horsepower vs. Speed: The horsepower (HP) consumed changes as the cube of the speed ratio (S)

$$\frac{HP_2}{HP_1} = \left(\frac{S_2}{S_1}\right)^3$$

Example: A blower operating at 1750 rpm (S_1) requires a 5 hp (HP_1) motor. How many horsepower (HP_2) will be required to handle a speed increase to 3500 rpm (S_2)?

$$HP_2 = HP_1 \left(\frac{S_2}{S_1}\right)^3 = 5 \times \left(\frac{3500}{1750}\right)^3$$

$$= 5 \times (2)^3 = 5 \times 8 = 40 \text{ hp}$$

Laws 1a, 1b and 1c are known as the 1-2-3 *rule* of centrifugal blowers. Volume increases in direct ratio, pressure as the square, and horsepower as the cube, of the speed ratio.

2. Effect of Air Density on Flow, Pressure, and Power Consumption.

a. Volume Flow vs. Density

Volume flow (cfm) remains constant regardless of density.

b. Weight Flow vs. Density: Weight flow (W) changes in direct ratio to the density (D) or specific gravity (G)

$$\frac{W_2}{W_1} = \frac{D_2}{D_1} = \frac{G_2}{G_1}$$

Example: A blower delivers 1500 lb/hr (20,000 cu ft/hr) (W_1) of air at standard conditions (density $D_1 = 0.075$ lb/cu ft). What will be the weight flow delivered if the air temperature is 250°F?

From page 21, air density (D_2) at 250°F is .056 lb/cu ft.

$$W_2 = W_1 \times \frac{D_2}{D_1} = 1500 \times \frac{.056}{.075} = 1120 \text{ lb/hr.}$$

c. Pressure vs. Density: Pressure (P) changes in direct proportion to density (D) or specific gravity (G).

$$\frac{P_2}{P_1} = \frac{D_2}{D_1} = \frac{G_2}{G_1}$$

Example: At sea level conditions ($G_1 = 1.0$), a blower develops 28" w.c. pressure (P_1). What pressure (P_2) will it develop at 4000 ft. altitude?

From page 20, air gravity (G_2) at 4000 ft is 0.86.

$$P_2 = P_1 \times \frac{G_2}{G_1} = 28 \times \frac{.86}{1.0} = 24.1\text{" w.c.}$$

d. Horsepower vs. Density: Horsepower (HP) consumed changes in direct proportion to density (D) or specific gravity (G).

$$\frac{HP_2}{HP_1} = \frac{D_2}{D_1} = \frac{G_2}{G_1}$$

Example: A standard air (G_1) blower requires a 10 hp (HP_1) motor. What horsepower (HP_2) is required if this blower is to handle a gas of 0.5 specific gravity (G_2)? The gravity of standard air is 1.0, so

$$HP_2 = HP_1 \times \frac{G_2}{G_1} = 10 \times \frac{0.5}{1.0} = 5 \text{ hp}$$