

# FAN LAWS

|   |   |  |  |
|---|---|--|--|
| <b>Rotational Speed</b>                   | Fan Size<br>Air Density<br>Duct System      | 1. Flow is directly proportional to speed                                | $q_1 = N_1$<br>$q_2 = N_2$                                     |
|   |   | 2. Pressure is directly proportional to speed <sup>2</sup>               | $P_1 = N_1^2$<br>$P_2 = N_2^2$                                 |
|   |   | 3. Air Power is directly proportional to speed <sup>3</sup>              | $A_1 = N_1^3$<br>$A_2 = N_2^3$                                 |
| <b>Fan Size &amp; Rotational Speed</b>    | Tip Speed<br>Air Density                    | 4. Flow and air power are directly proportional to diameter <sup>2</sup> | $q_1 = A_1 D_1^2$<br>$q_2 = A_2 D_2^2$                         |
|   |   | 5. Speed is inversely proportional to diameter                           | $N_1 = D_2$<br>$N_2 = D_1$                                     |
|   |   | 6. Pressure remains constant   | $P_1 = P_2$  |
| <b>Fan Size</b>                           | Rotational Speed<br>Air Density             | 7. Flow is directly proportional to diameter <sup>3</sup>                | $q_1 = D_1^3$<br>$q_2 = D_2^3$                                 |
|   |   | 8. Pressure is directly proportional to diameter <sup>2</sup>            | $P_1 = D_1^2$<br>$P_2 = D_2^2$                                 |
|   |   | 9. Air power is directly proportional to diameter <sup>5</sup>           | $A_1 = D_1^5$<br>$A_2 = D_2^5$                                 |
| <b>Rotational Speed &amp; Air Density</b> | Fan Size<br>Pressure                        | 10. Speed, flow and air power are inversely proportional to density      | $N_1 = q_1 = A_1 = p_2^{1/2}$<br>$N_2 = q_2 = A_2 = p_1^{1/2}$ |
| <b>Air Density</b>                        | Rotational Speed<br>Fan Size<br>Duct System | 11. Pressure and air power are directly proportional to density          | $P_1 = A_1 = p_1$<br>$P_2 = A_2 = p_2$                         |
|   |   | 12. Flow remains constant  | $q_1 = q_2$  |

## SYMBOLS

A = Air Power in watts  
D = Impeller diameter in metres  
N = Number of revolutions per second  
P = Total pressure in pascals  
q = Volume flow in m<sup>3</sup>/s  
p = Density in kg/m<sup>3</sup>

## NOTES

- Total Pressure = Static Pressure + Velocity Pressure
- $A = P \times q$
- Shaft Power =  $A / \text{Efficiency}$   
(Fan efficiencies usually range between 0.45 and 0.8)
- System resistance usually varies as the square of velocity
- Fan laws apply accurately only to geometrically similar fans operating at the same point on the characteristic curve