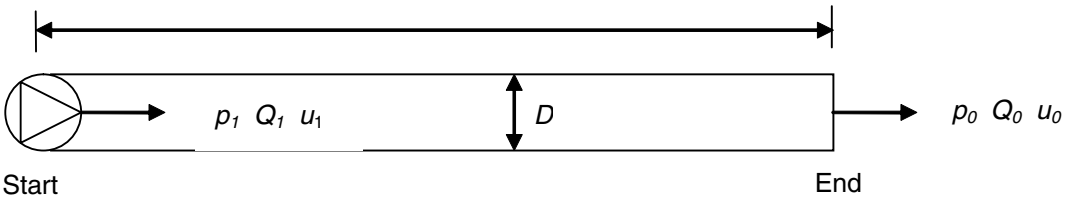
Protecting values

Theoretical basis for calculation of ventilation ducting performance



p_1 (Pa) is static pressure at ventilator.

p_0 (Pa) is static pressure at duct end. For free airflow at end with no constraints, $p_0 = 0$ Pa.

u_1 (m/s) is air speed at ventilator.

u_0 (m/s) is air speed at duct end.

Q_1 (m³/s) is air volume flow rate at ventilator.

Q_0 (m³/s) is air volume flow rate at duct end.

D (m) is tube diameter.

L (m) is tube length.

ρ (kg/m³) is the mass density of air.

The static pressure loss along a tube length L is given by: $$p_1 - p_0 = \lambda \cdot \frac{L}{D} \cdot \frac{\rho}{2} \cdot \left(\frac{u_1 + u_0}{2} \right)^2$$

Hence, the friction factor λ (-) can be calculated by: $$\lambda = \frac{p_1 - p_0}{\frac{L}{D} \cdot \frac{\rho}{2} \cdot \left(\frac{u_1 + u_0}{2} \right)^2}$$

The leakage factor f^* (mm²/m²) can be calculated by: $$f^* = \frac{\lambda}{8} \cdot \left[\left(\frac{u_1}{u_o} \right)^3 - 1 \right] \cdot \frac{\left(\frac{\rho}{2} \cdot u_0^2 \right)^{3/2}}{p_1^{3/2} - p_0^{3/2}}$$

If $p_0 = 0$, then the static pressure at the ventilator is: $$p_1 = \frac{\rho}{2} \cdot u_0^2 \cdot \left(\frac{\lambda}{8 \cdot f^*} \cdot \left[\left(\frac{u_1}{u_o} \right)^3 - 1 \right] \right)^{2/3}$$

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The total pressure at the ventilator is the sum of static pressure, dynamic pressure and singular pressure losses, where ζ_i is the loss factor (e.g. 0.1 at duct entrance and 1.7 at grid covered duct exit).

$$p_{VENT} = p_1 + \frac{\rho}{2} \cdot u_1^2 + \sum_1^i \zeta_i \cdot \frac{\rho}{2} \cdot u_i^2$$

The friction factor λ includes both losses from cross sectional changes and directional changes in addition to the wall friction in the tube.

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The necessary electrical power N (W) for the ventilator is given by:

$N = \frac{Q_1 \cdot p_{VENT}}{\eta_{VENT} \cdot \eta_{ENGINE}}$, where η_{VENT} and η_{ENGINE} are efficiency factors.

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