Natural Ventilation by Stack Effect

Natural (stack) ventilation flow through low and high openings from the height between them and the indoor–outdoor temperature difference.

Method: Buoyancy-driven flow Q = C_d A_e √(2gHΔT/T); openings in series 1/A_e² = 1/A₁² + 1/A₂² (CIBSE AM10; ASHRAE Handbook—Fundamentals ch. 16)

Input parameters

Unit system: SI

Parameter	Value	Unit
Free area of the low openings	4.0000	m²
Free area of the high openings	4.0000	m²
Height between opening centres	15.000	m
Indoor temperature	40.000	°C
Outdoor temperature	30.000	°C
Discharge coefficient	0.61000	
Air density for the heat removed 1.2 kg/m³ at about 20 °C; 1.13 at 40 °C. Used only for the heat removed.	1.2000	kg/m³

Calculated results

Parameter	Value	Unit
Effective area (openings in series)	2.8284	m²
Stack flow	19,038	m³/h
Heat removed ρ c_p V ΔT (c_p 1006 J/(kg·K))	63.841	kW

Notes for this case

- Wind adds to or works against the stack; the stack value is what you get on a still day.

Formula and method

$$\dot{V} = C_d A_e \sqrt{\frac{2gH|T_i - T_o|}{T_w}}, \quad T_w = \max(T_i, T_o), \quad \frac{1}{A_e^2} = \frac{1}{A_1^2} + \frac{1}{A_2^2}, \quad \dot{Q} = \rho c_p \dot{V} |T_i - T_o|$$

Variables

A_1	Free area of the low openings	m²
A_2	Free area of the high openings	m²
H	Height between opening centres	m
T_i	Indoor temperature	K
T_o	Outdoor temperature	K
C_d	Discharge coefficient	-
A_e	Effective area (openings in series)	m²
$\dot{V}$	Stack flow	m³/s
$\dot{Q}$	Heat removed ρ c_p V ΔT (c_p 1006 J/(kg·K))	W
ρ	Air density for the heat removed	kg/m³
c_p	Specific heat of air, 1 006	J/(kg·K)
T_w	The warmer of T_i and T_o (absolute)	K
g	Standard gravity, 9.806 65	m/s²

Method and standards

Bernoulli with buoyancy.

Assumptions and limits

- Still air, well-mixed interior.
- The buoyancy term divides by the warmer absolute temperature, so the same formula holds when the inside is colder than outside (flow reversed).
- The air density for the heat removed is an input (default 1.2 kg/m³); use the density at the outlet air temperature, about 1.13 kg/m³ at 40 °C.

References

- Buoyancy-driven flow $Q = C_d A_e \sqrt{(2gH\Delta T/T)}$
- openings in series $1/A_e^2 = 1/A_1^2 + 1/A_2^2$ (CIBSE AM10; ASHRAE Handbook—Fundamentals ch. 16)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/hvac/loads/stack-effect-ventilation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.