Flue Gas Velocity Through a Tube Bank

Free flow area across a row of tubes and the flue gas velocity through it from gas flow, temperature, pressure and molar mass (ideal gas), against an erosion limit.

Method: Free area A = L (W − n d); ideal gas density; velocity limit by fuel ash (user input)

Input parameters

Unit system: SI

Parameter	Value	Unit
Flue gas flow	160.00	t/h
Gas temperature in the bank	500.00	°C
Flue gas molar mass	28.500	kg/kmol
Gas pressure (absolute)	100.00	kPa
Duct width across the tubes	6.0000	m
Tube length exposed (duct depth)	5.0000	m
Tubes in one row	60.000	
Tube outside diameter	50.800	mm
Velocity limit for the fuel's ash	12.000	m/s

Calculated results

Parameter	Value	Unit
Free flow area	14.760	m²
Gas density	0.44335	kg/m³
Gas velocity	6.7918	m/s
Share of the limit	56.598	%

Formula and method

$$A_f = L(W - n d_o), \quad \rho_g = \frac{p M_g}{1000\, R T_g}, \quad v = \frac{\dot{m}_g}{\rho_g A_f}$$

Variables

$\dot{m}_g$	Flue gas flow	kg/s
T_g	Gas temperature in the bank	K
M_g	Flue gas molar mass	kg/kmol
p	Gas pressure (absolute)	Pa
W	Duct width across the tubes	m
L	Tube length exposed (duct depth)	m
n	Tubes in one row	-
d_o	Tube outside diameter	m
v_{lim}	Velocity limit for the fuel's ash	m/s
A_f	Free flow area	m²
ρ_g	Gas density	kg/m³
v	Gas velocity	m/s
R	universal gas constant, 8.314 J/(mol·K) (the 1000 converts M_g from kg/kmol)	J/(mol·K)
v/v_{lim}	Share of the limit	-

Method and standards

Continuity through the free area between the tubes of one row, with the ideal-gas density at the bank temperature and pressure.

Assumptions and limits

- Uniform flow.
- In-line banks: the gap between tubes of one row sets the area. In staggered banks the diagonal gap can be smaller and then sets the peak velocity; it is not computed here.

References

- Free area A = L (W − n d); ideal gas density; velocity limit by fuel ash (user input)

Report details

Report reference	FCC-4N6G-B0JT (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Flue Gas Velocity Through a Tube Bank
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	2 reference cases of this calculator, computed independently, are checked on every release

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

This calculator online

https://calc.firecad.com/boilers-power-plant/furnace-heating-surfaces/flue-gas-velocity-tube-bank

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Reopens the calculator with the inputs of this report.