Furnace Gas Residence Time and Volumetric Heat Release

Flue gas volume flow at furnace temperature (ideal gas), gas residence time in the furnace and the volumetric heat release from the heat input.

Method: Ideal gas density ρ = pM/(RT); residence time = V/$\dot{V}$; heat release = Q/V

Input parameters

Unit system: SI

Parameter	Value	Unit
Furnace volume	450.00	m³
Flue gas flow	160.00	t/h
Mean furnace gas temperature	1,000.0	°C
Flue gas molar mass	28.500	kg/kmol
Furnace pressure (absolute)	101.33	kPa
Heat input from fuel (GCV or NCV, as your limit states)	75.000	MW

Calculated results

Parameter	Value	Unit
Gas density at furnace temperature	0.27280	kg/m³
Gas volume flow	586,506	m³/h
Residence time	2.7621	s
Volumetric heat release	166.67	kW/m³

Notes for this case

- Biomass and slop furnaces need longer residence times than oil or gas to burn out volatiles and char.

Formula and method

$$\rho_g = \frac{pM_g}{1000\,RT_f}, \quad t_r = \frac{V_f \rho_g}{\dot{m}_g}, \quad q_v = \frac{\dot{Q}}{V_f}$$

Variables

V_f	Furnace volume	m³
$\dot{m}_g$	Flue gas flow	kg/s
T_f	Mean furnace gas temperature	K
M_g	Flue gas molar mass	kg/kmol
p	Furnace pressure (absolute)	Pa
$\dot{Q}$	Heat input (fuel)	W
ρ_g	Gas density at furnace temperature	kg/m³
$\dot{V}_g$	Gas volume flow	m³/s
t_r	Residence time	s
q_v	Volumetric heat release	W/m³
R	universal gas constant, 8.314 J/(mol·K) (the 1000 converts M_g from kg/kmol)	J/(mol·K)

Method and standards

Ideal-gas density at the mean furnace temperature; residence time is the furnace volume over the gas volume flow.

Assumptions and limits

- Uniform temperature; plug flow through the whole volume.

- The volumetric heat release is on the basis (GCV or NCV) of the heat input entered.
- A note appears below 2 s, the residence time waste-fuel rules often require.

References

- Ideal gas density ρ = pM/(RT); residence time = V/$\dot{V}$; heat release = Q/V

Report details

Report reference	FCC-6P4X-W5JV (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Furnace Gas Residence Time and Volumetric Heat Release
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/furnace-residence-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.