Flue Gas Cooling by Water Spray (Evaporative Quench)

Water to spray into flue gas to cool it to a target temperature, with full evaporation (IF97 vapour enthalpy at its partial pressure), and the water dew point of the cooled gas.

Method: Energy balance with IAPWS-IF97 enthalpies (water at inlet temperature to vapour at the gas outlet temperature)

Input parameters

Unit system: SI

Parameter	Value	Unit
Flue gas flow	100.00	t/h
Gas specific heat	1.1000	kJ/(kg·K)
Gas in	200.00	°C
Gas out (target)	150.00	°C
Spray water temperature	30.000	°C
Water vapour in the inlet gas, volume fraction (wet) From the flue gas analysis; about 0.06 to 0.10 for coal, 0.10 to 0.12 for oil, 0.18 for natural gas, 0.20 to 0.30 for wet biomass.	10.000	%
Molar mass of the inlet gas (wet) About 29.5 kg/kmol for coal flue gas, 28 for natural gas flue gas.	29.500	kg/kmol
Gas pressure (absolute)	1.0132	bar

Calculated results

Parameter	Value	Unit
Heat removed from the gas	1,527.8	kW
Spray water	2,070.0	kg/h
Water per kg of gas	20.700	g/kg
Water vapour partial pressure at the outlet	13.122	kPa
Water dew point of the cooled gas	51.226	°C

Notes for this case

- Allow residence time and fine atomisation for the droplets to evaporate fully.
- Water dew point only; an acid (SO_3) dew point, if the gas carries sulphur, is higher.

Formula and method

$$\dot{Q} = \dot{m}_g c_{p,g}(T_1 - T_2), \quad \dot{m}_w = \frac{\dot{Q}}{h_v(p_{v,2}, T_2) - h_l(T_w)}$$

$$p_{v,2} = p\,\frac{y_w \dot{m}_g/M_g + \dot{m}_w/M_{H_2O}}{\dot{m}_g/M_g + \dot{m}_w/M_{H_2O}}, \quad T_{dp} = T_{sat}(p_{v,2})$$

Variables

$\dot{m}_g$	Flue gas flow	kg/s
$c_{p,g}$	Gas specific heat	J/(kg·K)
T_1	Gas in	K
T_2	Gas out (target)	K
T_w	Spray water temperature	K

y_w	Water vapour in the inlet gas, volume fraction (wet)	-
M_g	Molar mass of the inlet gas (wet)	kg/kmol
M_{H_2O}	Molar mass of water, 18.015	kg/kmol
p	Gas pressure, absolute	Pa
$\dot{Q}$	Heat removed from the gas	W
$\dot{m}_w$	Spray water	kg/s
$\dot{m}_w/\dot{m}_g$	Water per kg of gas	kg/kg
$p_{v,2}$	Water vapour partial pressure at the outlet	Pa
T_{dp}	Water dew point of the cooled gas	K
T_{sat}	Saturation temperature of water (IF97)	K
h_v	Water vapour enthalpy at its partial pressure and the outlet temperature (IF97)	J/kg
h_l	Liquid water enthalpy at the spray temperature (IF97)	J/kg

Method and standards

Energy balance: the heat the gas gives up evaporates the spray water and heats the vapour to the outlet temperature. The vapour enthalpy is taken from IAPWS-IF97 at the outlet temperature and at the vapour's own partial pressure in the cooled gas, which depends on the water sprayed, so the balance is solved by iteration. The water dew point is the saturation temperature at that partial pressure.

Assumptions and limits

- Complete evaporation; the gas specific heat is a mean value and the inlet gas composition is given by its water vapour fraction and molar mass.
- A note appears when the outlet is less than 20 K above the water dew point; the calculation fails when the outlet would be saturated.
- The acid (SO_3) dew point, if the gas carries sulphur, is higher than the water dew point and is not computed here.

References

- Energy balance with IAPWS-IF97 enthalpies (water at inlet temperature to vapour at the gas outlet temperature)

Report details

Report reference	FCC-4SW5-N15N (the same inputs always give the same reference)
Generated	17 November 2026, 19:49 UTC
Calculator	Flue Gas Cooling by Water Spray (Evaporative Quench)
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 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/emissions-stacks/flue-gas-spray-cooling

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.