Flue Gas Cooling by Dilution Air

Ambient air to mix with hot flue gas to reach a target temperature, and the extra gas mass flow the fan and filter must then handle.

Method: Energy balance ṁ_a c_p; a (T_m − T_a) = ṁ_g c_p; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Flue gas flow	100.00	t/h
Gas specific heat	1.1000	kJ/(kg·K)
Gas temperature	250.00	°C
Target mixed temperature	150.00	°C
Ambient air temperature	30.000	°C
Air specific heat	1.0060	kJ/(kg·K)

Calculated results

Parameter	Value	Unit
Dilution air	91.120	t/h
Air per kg of gas	0.91120	kg/kg
Total gas after mixing	191.12	t/h

Notes for this case

- Dilution raises the gas flow and the fan power; compare with spray cooling.

Formula and method

$$\dot{m}_a = \frac{\dot{m}_g c_{p,g} (T_g - T_m)}{c_{p,a} (T_m - T_a)}$$

Variables

$\dot{m}_g$	Flue gas flow	kg/s
$c_{p,g}$	Gas specific heat	J/(kg·K)
T_g	Gas temperature	K
T_m	Target mixed temperature	K
T_a	Ambient air temperature	K
$c_{p,a}$	Air specific heat	J/(kg·K)
$\dot{m}_a$	Dilution air	kg/s
$\dot{m}_a/\dot{m}_g$	Air per kg of gas	kg/kg
$\dot{m}_t$	Total gas after mixing	kg/s

Method and standards

Energy balance between the gas cooling from T_g to T_m and the air warming from T_a to T_m. The output is the mass flow; convert it to volume at the fan temperature with the gas density there.

Assumptions and limits

- Constant specific heats: use the mean gas value between T_m and T_g and the mean air value between T_a and T_m. From very hot gas (above about 1000 °C) the mean gas specific heat is noticeably higher than at the stack.
- A warning appears above 3 kg of air per kg of gas.

References

- Energy balance ṁ_a c_p
- a (T_m − T_a) = ṁ_g c_p
- g (T_g − T_m)

Report details

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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/emissions-stacks/dilution-air-cooling

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.