Limestone for SO_2 Capture (Ca/S Ratio)

Limestone feed for in-bed or dry SO_2 capture from the fuel sulphur, Ca/S molar ratio and limestone purity, with the SO_2 left and the $CaSO_4$ and CaO formed.

Method: Reaction stoichiometry $CaCO_3 + SO_2 + ½O_2 \rightarrow CaSO_4 + CO_2$; IUPAC atomic weights

Input parameters

Unit system: SI

Parameter	Value	Unit
Fuel firing rate	50,000	kg/h
Sulphur in the fuel, as fired	0.50000	%
Ca/S molar ratio From the boiler maker for the capture wanted; fluidised beds typically need 1.5–3.	2.0000	
$CaCO_3$ in the limestone, by mass	92.000	%
SO_2 capture efficiency	90.000	%

Calculated results

Parameter	Value	Unit
Limestone feed	1.6966	t/h
Limestone per kg of fuel	0.033933	kg/kg
SO_2 formed from the fuel sulphur	499.52	kg/h
SO_2 leaving after capture	49.952	kg/h
$CaSO_4$ formed	955.40	kg/h
Unreacted CaO	481.01	kg/h
Inerts in the limestone (to the ash)	135.73	kg/h

Formula and method

$$\dot{n}_S = \frac{\dot{m}_f S}{M_S} \qquad \dot{m}_{ls} = \frac{Ca/S \cdot \dot{n}_S M_{CaCO_3}}{x_{CaCO_3}} \qquad \dot{m}_{SO_2,0} = \dot{n}_S M_{SO_2} \qquad \dot{m}_{SO_2} = (1-\eta_s)\,\dot{m}_{SO_2,0}$$

$$\dot{m}_{CaSO_4} = \eta_s \dot{n}_S M_{CaSO_4} \qquad \dot{m}_{CaO} = (Ca/S - \eta_s)\,\dot{n}_S M_{CaO} \qquad \dot{m}_{in} = (1-x_{CaCO_3})\,\dot{m}_{ls}$$

Variables

$\dot{m}_f$	fuel firing rate	kg/s
S	sulphur in the fuel as fired	–
Ca/S	calcium to sulphur molar ratio	–
x_{CaCO_3}	$CaCO_3$ in the limestone by mass	–
η_s	SO_2 capture efficiency	–
$\dot{m}_{ls}$	limestone feed	kg/s
$\dot{m}_{ls}/\dot{m}_f$	limestone per kg of fuel	kg/kg
$\dot{m}_{SO_2,0}$	SO_2 formed from the fuel sulphur	kg/s
$\dot{m}_{SO_2}$	SO_2 leaving after capture	kg/s
$\dot{m}_{CaSO_4}$	$CaSO_4$ formed	kg/s
$\dot{m}_{CaO}$	unreacted CaO	kg/s
$\dot{m}_{in}$	inerts in the limestone, to the ash	kg/s
$\dot{n}_S$	sulphur, molar flow	kmol/s

M_S, M_{CaCO_3}, M_{SO_2}, M_{CaSO_4}, M_{CaO}	molar masses (32.06, 100.09, 64.06, 136.13, 56.08)	kg/kmol

Method and standards

Stoichiometry of calcination and sulphation ($CaCO_3 \rightarrow CaO + CO_2$; $CaO + SO_2 + ½O_2 \rightarrow CaSO_4$) with IUPAC atomic weights. All fuel sulphur is taken to form SO_2.

Assumptions and limits

- Magnesium carbonate in dolomitic limestone also captures some SO_2; it is not counted.
- CO_2 released by calcination is not included here (see the CO_2 emission factor).
- The Ca/S needed for a capture efficiency depends on the bed, the limestone and the temperature; it is your input. The capture entered is checked only against Ca/S (capture cannot exceed it), not against a Ca/S–capture curve.
- Sorbent ash is the $CaSO_4$ formed, the unreacted CaO and the limestone inerts together.

References

• Reaction stoichiometry $CaCO_3 + SO_2 + ½O_2 \rightarrow CaSO_4 + CO_2$; IUPAC atomic weights

Report details

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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/limestone-for-desulphurisation

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Reopens the calculator with the inputs of this report.