Boiler Phosphate Dosing Rate

Phosphate (TSP) dosing rate for boiler water from feedwater flow and hardness, blowdown and the phosphate residual to keep in the boiler water.

Method: Calcium phosphate stoichiometry (3 Ca : 2 PO4); IUPAC 2013 atomic weights

Input parameters

Unit system: SI

Parameter	Value	Unit
Feedwater flow	10,000	kg/h
Feedwater hardness, as $CaCO_3$	2.0000	ppm
Blowdown, share of feedwater	5.0000	%
Phosphate residual to keep in the boiler water, as PO_4 From your water chemistry limits for the boiler pressure.	30.000	ppm
PO_4 content of the product Trisodium phosphate dodecahydrate is about 25 % PO_4; anhydrous about 58 %.	25.000	%

Calculated results

Parameter	Value	Unit
Phosphate feed, as PO_4	0.027652	kg/h
Product feed	0.11061	kg/h
Dose in the feedwater, as PO_4	2.7652	ppm
PO_4 per unit of hardness as $CaCO_3$	0.63259	kg/kg

Formula and method

$$r = \frac{2\,M_{PO_4}}{3\,M_{CaCO_3}} \qquad \dot{m}_{PO_4} = \dot{m}_{fw}\left(H\,r + b\,R_{PO_4}\right) \qquad \dot{m}_p = \frac{\dot{m}_{PO_4}}{w} \qquad D = \frac{\dot{m}_{PO_4}}{\dot{m}_{fw}}$$

Variables

$\dot{m}_{fw}$	feedwater flow	kg/s
H	feedwater hardness as $CaCO_3$	–
b	blowdown, share of feedwater	–
R_{PO_4}	phosphate residual in boiler water	–
w	PO_4 content of the product	–
$\dot{m}_{PO_4}$	phosphate feed as PO_4	kg/s
$\dot{m}_p$	product feed	kg/s
D	dose in the feedwater	–
r	PO_4 per unit hardness as $CaCO_3$	kg/kg
M	molar masses from IUPAC atomic weights	kg/kmol

Method and standards

Phosphate to precipitate hardness as calcium phosphate (3 Ca : 2 PO_4), plus the phosphate leaving with the blowdown at the residual concentration.

Assumptions and limits

- All hardness reacts as calcium phosphate; residual measured as PO_4.
- The 3 Ca : 2 PO_4 ratio of tricalcium phosphate is a simple stoichiometric basis, not taken from a cited treatment standard. In alkaline boiler water calcium often precipitates as hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$, which takes less phosphate (r ≈ 0.569), and magnesium hardness does not form calcium phosphate; the result is then on the high side.

References

- Calcium phosphate stoichiometry (3 Ca : 2 PO4)
- IUPAC 2013 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/water-treatment/phosphate-dose

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Reopens the calculator with the inputs of this report.