Chemical Phosphorus Removal: Alum or Ferric Chloride Dose

Alum or ferric chloride needed to precipitate phosphorus from a molar metal-to-phosphorus ratio, as dry chemical and as a solution volume.

Method: Metcalf & Eddy; Wastewater Engineering: Treatment and Resource Recovery; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Flow	10,000	m^3/d
Phosphorus to remove	5.0000	mg/L
Chemical	Alum $Al_2(SO_4)_3 \cdot 14H_2O$	
Molar metal-to-phosphorus ratio	2.0000	
Solution strength (mass fraction of the product named above: alum as the 14-hydrate, ferric chloride as $FeCl_3$)	48.000	%
Solution density	1,330.0	kg/m^3

Calculated results

Parameter	Value	Unit
Metal dose (as Al or Fe)	8.7112	mg/L
Dry chemical	959.51	kg/d
Solution volume	62.625	L/h

Notes for this case

- Molar ratios of 1.5–2.5 are typical to reach 0.5–1 mg/L total P; lower effluent targets need higher ratios. Jar tests set the dose. Alum solution is often 48 % at 1.33 kg/L; ferric chloride 40 % at 1.42 kg/L.

Formula and method

$$n_M = \frac{\Delta P}{30.974} \cdot (M:P), \quad C_M = n_M A_M, \quad \dot{m} = n_M \frac{M_{chem}}{\nu_M} Q, \quad \dot{V} = \frac{\dot{m}}{w\rho}$$

Variables

Q	Flow	m^3/s
ΔP	Phosphorus to remove	kg/m^3
$\mathrm{chemical}$	Chemical	-
$M:P$	Molar metal-to-phosphorus ratio	-
w	Solution strength (mass fraction)	-
ρ	Solution density	kg/m^3
C_M	Metal dose (as Al or Fe)	kg/m^3
n_M	Metal to add, molar	$kmol/m^3$
A_M	Atomic mass of the metal	kg/kmol
M_{chem}/ν_M	Product mass per kmol of metal	kg/kmol
$\dot{m}$	Dry chemical	kg/s
$\dot{V}$	Solution volume	m^3/s

Method and standards

Stoichiometry.

Assumptions and limits

- Molar ratio from jar tests or practice.

- n_M is the metal in kmol per m^3; A_M is 26.982 kg/kmol for Al and 55.845 kg/kmol for Fe. M_chem/v_M is the product mass per mole of metal: 594.4/2 kg/kmol for $Al_2(SO_4)_3 \cdot 14H_2O$, 162.2 kg/kmol for $FeCl_3$.
- Solution strength as the 14-hydrate for alum; a strength quoted as anhydrous $Al_2(SO_4)_3$ or as Al_2O_3 must be converted first.

References

- Metcalf & Eddy
- Wastewater Engineering: Treatment and Resource Recovery
- 5th ed. (McGraw-Hill, 2014)
- ch. 6 (chemical phosphorus removal, molar ratios)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/environmental/wastewater/chemical-phosphorus-removal

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Reopens the calculator with the inputs of this report.