Ferrous Iron Oxidation by Aeration: Rate, CMFR and PFR Volume

Pseudo-first-order rate of ferrous iron oxygenation from pH and oxygen, and the detention time and volume of completely mixed or plug-flow reactors.

Input parameters

Unit system: SI

Parameter	Value	Unit
Initial ferrous iron	3.0000	mg/L
Target ferrous iron	0.10000	mg/L
pH	6.5000	
Oxygen partial pressure (air 0.21 atm)	0.21000	
Rate constant (Stumm and Lee: 8 × 10^{13} $L^2/(mol^2 \cdot atm \cdot min)$ at 20 °C)	8.0000e+13	
Flow	2,000.0	m^3/d

Calculated results

Parameter	Value	Unit
Pseudo-first-order rate constant	0.016800	1/min
Completely mixed reactor detention	1,726.2	min
Completely mixed reactor volume	2,397.5	m^3
Plug-flow reactor detention	202.45	min
Plug-flow reactor volume	281.18	m^3
Half-life of Fe^{2+}	41.259	min

Notes for this case

- Rate law −d[Fe^{2+}]/dt = k[OH^-]²P_O_2[Fe^{2+}] (Stumm and Lee) with [OH^-] from pK_w = 14. The rate rises 100-fold per pH unit; iron bound to natural organic matter oxidises far more slowly, so confirm by bench tests.

Formula and method

$$-\frac{d[\mathrm{Fe}^{2+}]}{dt} = k[\mathrm{OH}^-]^2 P_{O_2}[\mathrm{Fe}^{2+}] = k_r[\mathrm{Fe}^{2+}]$$

$$\tau_{CMFR} = \frac{C_0 - C_e}{k_r C_e}, \quad \tau_{PFR} = \frac{1}{k_r}\ln\frac{C_0}{C_e}$$

Variables

C_0	Initial ferrous iron	kg/m^3
C_e	Target ferrous iron	kg/m^3
pH	pH	-
P_{O_2}	Oxygen partial pressure (air 0.21 atm)	-
k	Rate constant (Stumm and Lee: 8 × 10^{13} $L^2/(mol^2 \cdot atm \cdot min)$ at 20 °C)	-
Q	Flow	m^3/s
k_r	Pseudo-first-order rate constant	1/s
τ_{CMFR}	Completely mixed reactor detention	s

V_{CMFR}	Completely mixed reactor volume	m³
τ_{PFR}	Plug-flow reactor detention	s
V_{PFR}	Plug-flow reactor volume	m³
$t_{1/2}$	Half-life of Fe^{2+}	s

Method and standards

Stumm–Lee oxygenation kinetics with ideal reactor models.

Assumptions and limits

- pH above 5.5, no complexing organics, oxygen in excess.

Report details

Report reference	FCC-CZM2-HAXN (the same inputs always give the same reference)
Generated	23 November 2026, 17:34 UTC
Calculator	Ferrous Iron Oxidation by Aeration: Rate, CMFR and PFR Volume
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 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/environmental/drinking-water/ferrous-iron-oxidation-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.