UV Photolysis Reactor: Rate Constant and Treatable Flow

Photon flux per volume, first-order photolysis rate constant of a micropollutant and the flow a UV reactor treats for a target removal with tanks in series.

Method: Photolysis rate in optically thick water k = Φ P_UV 2.303ε/k' with tanks-in-series hydraulics

Input parameters

Unit system: SI

Parameter	Value	Unit
Number of lamps	8.0000	
Electrical power per lamp	10.000	kW
Lamp efficiency to UV at the working wavelength	15.000	%
Wavelength	254.00	nm
Reactor water volume	1,500.0	L
Molar absorption coefficient of the target (decadic)	1,650.0	
Quantum yield, mol/einstein	0.30000	
Water absorption coefficient (natural-log basis)	0.25000	1/cm
Equivalent tanks in series	5.0000	
Influent concentration	0.050000	ng/L
Target effluent concentration	0.005000	ng/L

Calculated results

Parameter	Value	Unit
Photon flux per volume, einstein/(L·s)	1.6986e-05	
Photolysis rate constant	0.077442	1/s
Hydraulic residence time needed	37.763	s
Flow that can be treated	39.721	L/s
Electrical energy per order	0.55946	kWh/m³
Orders of removal	1.0000	

Notes for this case

• Optically thick water (all UV absorbed by the water): k = Φ P_UV ε' / k', with ε' = 2.303ε. Wall and sleeve losses are not included; the removal follows n equal mixed tanks in series.

Formula and method

$$P_{UV} = \frac{n_l P_l \eta_{UV} \lambda}{hcN_A V}, \quad k = \frac{\Phi P_{UV} 2.303\,\varepsilon}{k'}$$

$$\tau = \frac{n}{k}\left[\left(\frac{C_0}{C_e}\right)^{1/n} - 1\right], \quad Q = \frac{V}{\tau}, \quad EE/O = \frac{n_l P_l}{Q \log(C_0/C_e)}$$

Variables

n_l	Number of lamps	-
P_l	Electrical power per lamp	W
η_{UV}	Lamp efficiency to UV at the working wavelength	-

λ	Wavelength	m
V	Reactor water volume	m³
ε	Molar absorption coefficient of the target (decadic)	-
Φ	Quantum yield, mol/einstein	-
k'	Water absorption coefficient (natural-log basis)	1/m
n	Equivalent tanks in series	-
C_0	Influent concentration	kg/m³
C_e	Target effluent concentration	kg/m³
P_{UV}	Photon flux per volume, einstein/(L·s)	-
k	Photolysis rate constant	1/s
τ	Hydraulic residence time needed	s
Q	Flow that can be treated	m³/s
EE/O	Electrical energy per order	J/m³
$\log(C_0/C_e)$	Orders of removal	-

Method and standards

Direct photolysis kinetics with photon balance and tanks-in-series flow.

Assumptions and limits

- Monochromatic light; no wall or sleeve losses; optically thick.

References

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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/environmental/drinking-water/uv-photolysis-reactor

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.