Spray Aeration: Nozzle Count, Drop Contact Time and Removal

Nozzle flow and count, drop velocity and contact time, liquid-side coefficient by penetration theory and the removal of a dissolved gas in spray aeration.

Input parameters

Unit system: SI

Parameter	Value	Unit
Water flow	0.020000	m^3/s
Head available at the nozzles	15.000	m
Nozzle diameter	20.000	mm
Nozzle discharge coefficient	30.000	%
Nozzle velocity coefficient	50.000	%
Spray angle from horizontal	60.000	°
Drop (Sauter mean) diameter	2.0000	mm
Liquid diffusivity of the gas	1.4000e-09	m^2/s
Dissolved gas in the feed	5.0000	mg/L

Calculated results

Parameter	Value	Unit
Flow per nozzle	1.6166	L/s
Nozzles required	13.000	
Drop exit velocity	8.5761	m/s
Drop contact time	1.5147	s
Penetration ratio (Higbie valid below 0.22)	0.046050	
Liquid-side mass transfer coefficient	0.034305	mm/s
Specific interfacial area	3,000.0	1/m
Volumetric coefficient	0.10291	1/s
Dissolved gas after spraying	4.2783	mg/L
Removal	14.434	%

Notes for this case

- Higbie penetration theory for drops in flight, with the stripped gas assumed to have negligible concentration in the air (high Henry's constant, e.g. CO_2, H_2S, radon).

Formula and method

$$Q_n = C_d A_n \sqrt{2gh}, \quad v_d = C_v \sqrt{2gh}, \quad t = \frac{2 v_d \sin\alpha}{g}$$

$$K_L = 2\left(\frac{D_l}{\pi t}\right)^{1/2}, \quad a = \frac{6}{d_d}, \quad C_e = C_0 e^{-K_L a t}$$

Variables

Q	Water flow	m^3/s

h	Head available at the nozzles	m
d_n	Nozzle diameter	m
C_d	Nozzle discharge coefficient	-
C_v	Nozzle velocity coefficient	-
α	Spray angle from horizontal	rad
d_d	Drop (Sauter mean) diameter	m
D_l	Liquid diffusivity of the gas	m²/s
C_0	Dissolved gas in the feed	kg/m³
Q_n	Flow per nozzle	m³/s
N	Nozzles required	-
v_d	Drop exit velocity	m/s
t	Drop contact time	s
$2\sqrt{D_l t}\,/d_d$	Penetration ratio (Higbie valid below 0.22)	-
K_L	Liquid-side mass transfer coefficient	m/s
a	Specific interfacial area	1/m
$K_L a$	Volumetric coefficient	1/s
C_e	Dissolved gas after spraying	kg/m³
R	Removal	-

Method and standards

Penetration-theory mass transfer to free-flying drops.

Assumptions and limits

- Short contact; gas phase concentration negligible.

Report details

Report reference	FCC-X8WA-R14G (the same inputs always give the same reference)
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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/drinking-water/spray-aeration-removal

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.