Limiting Current Density and Oxygen-Controlled Corrosion Rate

Diffusion-limited current density of a cathodic reaction such as oxygen reduction, and the corrosion rate it supports, from diffusivity and boundary layer.

Method: Concentration polarisation and diffusion control

Input parameters

Unit system: SI

Parameter	Value	Unit
Diffusivity of the reactant	2.0000e-05	cm^2/s
Bulk concentration of the reactant	0.26000	mmol/L
Electrons per reactant molecule (O_2: 4)	4.0000	
Diffusion boundary layer thickness	0.50000	mm
Corroding metal molar mass	55.845	kg/kmol
Metal valence	2.0000	
Metal density	7,870.0	kg/m^3

Calculated results

Parameter	Value	Unit
Limiting current density	0.40138	A/m^2
Equivalent uniform corrosion rate	0.46578	mm/a
Mass loss rate	10.036	$g/(m^2 \cdot d)$

Notes for this case

• Concentration polarisation: a cathodic reaction cannot run faster than its reactant diffuses through the boundary layer, i_L = nFDC_B/δ. In neutral aerated water, corrosion of steel is controlled by oxygen reduction at this limit, so the corrosion rate equals i_L converted by Faraday's law. Stirring or flow thins δ and raises the rate; deaeration lowers C_B. Air-saturated water at 25 °C holds about 0.26 mol/m^3 O_2.

Formula and method

$$i_L = \frac{nFDC_B}{\delta}, \quad CR = \frac{i_L M}{zF\rho}$$

Variables

D	Diffusivity of the reactant	m^2/s
C_B	Bulk concentration of the reactant	mol/m^3
n	Electrons per reactant molecule (O_2: 4)	-
δ	Diffusion boundary layer thickness	m
M	Corroding metal molar mass	kg/kmol
z	Metal valence	-
ρ	Metal density	kg/m^3
i_L	Limiting current density	A/m^2
CR	Equivalent uniform corrosion rate	m/s
$\dot{m}''$	Mass loss rate	$kg/(m^2 \cdot s)$

Method and standards

Limiting current.

Assumptions and limits

- Diffusion-controlled cathode; uniform corrosion.

References

Concentration polarisation and diffusion control

Report details

Report reference	FCC-BEYH-Y4ZF (the same inputs always give the same reference)
Generated	23 November 2026, 18:18 UTC
Calculator	Limiting Current Density and Oxygen-Controlled Corrosion Rate
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/materials/corrosion/limiting-current-density

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.