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Supplementary Information

AC-Induced Corrosion of Underground Steel Pipelines. Faradaic Rectification under Cathodic Protection: I. Theoretical Approach with Negligible Electrolyte Resistance

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List of Symbols

Alphabetic

$[O_2]_\infty$	Bulk concentration of dissolved oxygen	mol cm^{-3}
$[O_2]_{int}$	Interface concentration of dissolved oxygen	mol cm^{-3}
$<E_{corr,AV}>$	Dimensionless corrosion potential shift; = $(E_{corr,AV} - E_{corr,0}) / \Delta E$	
$<I_{corr,AV}>$	Dimensionless corrosion current; = $I_{corr,AV} / I_{corr,0}$	
B	Kinetic coefficient or Tafel constant (= $\pm\alpha\, n$ F / R T)	V^{-1}
C_d	Double layer capacitance	F cm^{-2}
CP	Cathodic protection	
D_{O_2}	Diffusion coefficient of dissolved oxygen	cm^2 s^{-1}
E	Potential at the interface	V
E_0	DC component of $E(t)$ corresponding to the CP potential	V
$E_{corr,0}$	Free corrosion potential or open circuit potential in absence of AC perturbation	V
F	Faraday (= 96500)	A s
f	Frequency of AC signal	Hz
I	Current density (+ for anodic and – for cathodic reaction)	A cm^{-2}
I_0	Corrosion current density under CP without AC signal	A cm^{-2}
$I_{B,k}$	Bessel function of kth order	
$I_{corr,0}$	So-called "free" corrosion current density	A cm^{-2}
I_{dif}	Diffusion component of the mixed kinetics	A cm^{-2}
I_F	Faradaic current	A cm^{-2}
K	Reaction rate constant	mol s^{-1}
n	Number of electrons exchanged in anodic reaction	
R	Gas constant (= 8.315)	J mol^{-1} K^{-1}
r_{diff,O_2}	Importance of the I_{diff} at $E_{corr,0}$; $-(1 - \lambda_{H_2O})\, I_{corr,0} / I_{lim,O_2}$ at $E_{corr,0}$	
R_E	Electrolyte resistance	Ω cm^2
$r_{O_2/a}$	Ratio of Tafel constant ($-b_{c,O_2} / b_a$)	
R_p	Polarisation resistance	Ω cm^2
T	Absolute temperature	K
U	Overall potential between the reference and working electrodes	V

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Greek symbols

$<\Delta E>$	Reduced amplitude of AC signal	
α	Transfer coefficient for tafelian process; between 0 and 1	
β	Tafel slope	V decade^{-1}
δ	Thickness of Nernst diffusion layer	cm
ΔE	Peak voltage of AC perturbing interacial signal	V
ΔU	Peak voltage of AC signal	V
λ_{H_2O}	Fraction of water reduction current at $E_{corr,0}$; $I_{corr,0,H_2O}$ / $I_{corr,0}$	
O_{O_2}	Flux of dissolved oxygen towards the electrode interface	mol s^{-1} cm^{-2}
ω	Angular frequency, pulsation (= $2\pi f$)	rad s^{-1}

Subscripts and suffixes

–	Mean value over one period of AC signal
a	Anodic reaction
c	Cathodic reaction
c,H_2O	Cathodic reaction of the water reduction reaction
c,O_2	Cathodic reaction of the dissolved oxygen reduction reaction
corr,0	At the free corrosion without AC perturbation