Calculating corrosion rates using LPR and EIS

Andrew McCaskill

GAMRY INSTRUMENTS

Outline

- Summary of Linear Polarization Resistance (LPR) and Electrochemical Impedance Spectroscopy (EIS)
- Demonstration of performing LPR and EIS experiments
- How to calculate the corrosion rate from the data

Linear Polarization Resistance

- LPR is an “active” technique
- It is fast and relatively simple
- Must have stable Open Circuit Potential (OCP)
- Scan over a small potential range relative to OCP to maintain linearity
- Slope of Voltage (V) vs. Current (I) is polarization resistance (Rp)

Linear Polarization Resistance

1. Monitor OCP and allow to stabilize.

2. Apply initial Voltage that is 10-15 mV negative of OCP.

3. Scan at a slow scan rate (~0.125 mV/s) to a final voltage that is 10-15 mV positive of OCP and monitor the current.

4. Plot Voltage (Y-axis) versus Current (X-axis), and measure the slope which is Rp (V=IR)

5. Convert R_p to i_{corr} using the Stern-Geary Equation.

6. Convert i_{corr} to Corrosion Rate.

Calculation of I_{CORR} from R_P

Stern-Geary Equation

$$\Delta V/\Delta i = R_P = \beta_a\beta_c/2.3\ i_{CORR}\ (\beta_a + \beta_c)$$

Where

R_P = Slope at the origin of the Polarization Resistance Plot in ohms or ohms-cm^2

i_{CORR} = Corrosion Current, Amperes or Amperes/cm^2.

β_a, β_c = Tafel Constants from a Tafel Curve, volts/decade of current.

Note: The area of the electrode must be taken into account

Calculation of Corrosion Rate from I_{CORR}

- Corrosion Rate (mpy) = 0.13 I_{corr} (EW)/d

Where

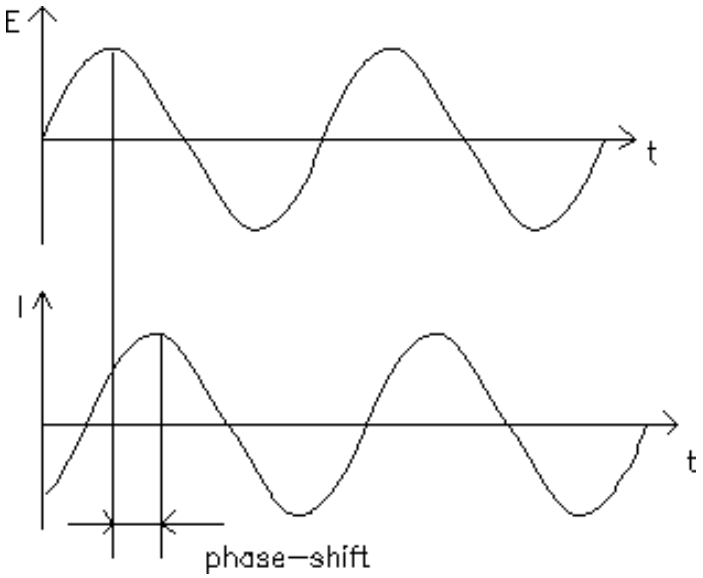
mpy is milli-inches per year

EW is the equivalent weight

d is the density in g/cm^3

Electrochemical Impedance Spectroscopy

- EIS is measured by applying an AC potential and then measuring the resulting current and phase angle through the cell
- Measured using a small excitation signal so that the cell's response is pseudo-linear, ~10 mV.



Electrochemical Impedance Spectroscopy

- Polarization resistance can be found through the resulting data using equivalent circuit modeling