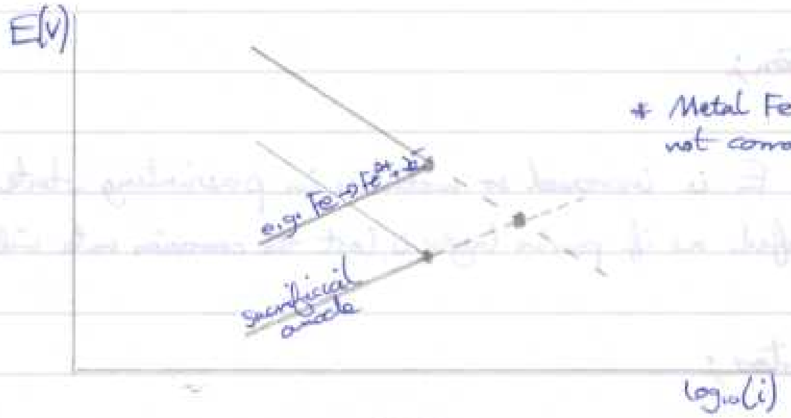
Corrosion Control Methods;

* Thermodynamic Methods; make metal immune/passive by altering electrode potential.
* Kinetic Methods; reduce corrosion rate (inhibitor addition).
* Barrier Methods; prevent contact between metal surface and solution.

Sacrificial Anodes;

* Make the $M \rightarrow M^{n+}$ reaction occur at the cathode. So electrically contact your material with a more reactive metal in the galvanic series.
* e.g. use Zn, Mg or Al as a sacrificial anode for protecting Cu or Fe. Ti can't be used as it has a passivation layer making it inert.

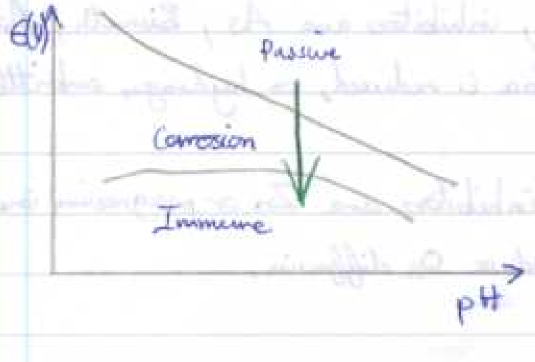


* Metal Fe becomes cathode so does not corrode.

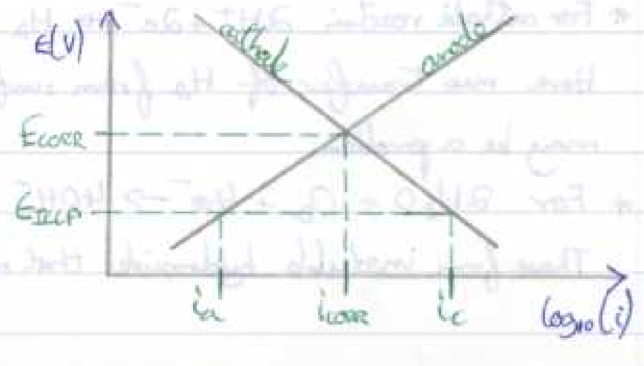
* Sacrificial anodes have a "THROWING POWER". As the protected metal has a resistance, it is better to have lots of small anodes than fewer large ones.
* Hydrogen Embrittlement may occur at the cathode.

Impressed Current Cathodic Protection (ICCP);

* Recall Pourbaix;



Recall Evans;



* Can see that imposing a potential can make a metal either thermodynamically immune or reduce its corrosion rate by a great deal.
* A potentiostat can keep E_{ICCP} fixed. We need $I = A(i_c - i_A)$ from Evan's.

* Comparing ICCP to sacrificial anodes:

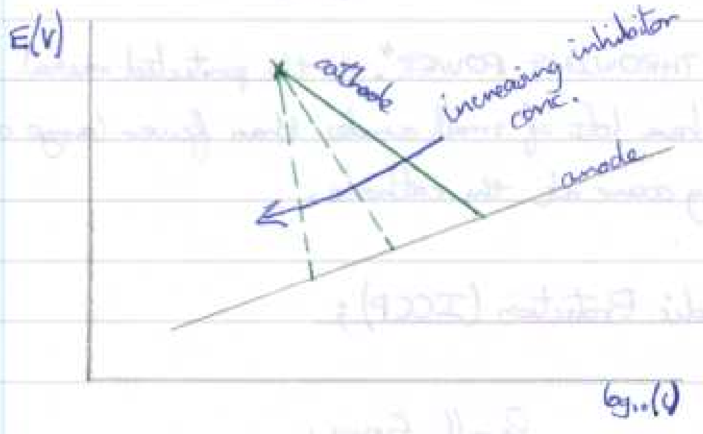
Advantages	Disadvantages
- Don't need to replace anode	- Circuits can go wrong!
- Electronics can control current supply	- Choosing E_{ICCP} is difficult.

* If E_{ICCP} is too -ve, passivating layers can be destroyed and hydrogen embrittlement may also occur.

Anodic Protection;

* This is where E is increased so metal is in passivating state. However must be careful as if passive layer is lost the corrosion rate will be high.

Cathodic Inhibitors;



* For cathodic reaction $2H^+ + 2e^- \rightarrow H_2$, inhibitors are As, Bismuth, Antimony ions. Here mass transfer of H_2 from surface is reduced, so hydrogen embrittlement may be a problem.
* For $2H_2O + O_2 + 4e^- \rightarrow 4OH^-$ inhibitors are Zn or magnesium ions. These form insoluble hydroxides that reduce O_2 diffusion.

Anodic Inhibitors;

* Oxidising agents such as chromates, nitrates and ferrates ~~[illegible]~~ preserve passivation layers.
* Other inhibitors react with metal ions to give an insoluble product that blocks the anode.
* If too little inhibitor is added, $A_a << A_c$ so corrosion gets WORSE!

Other Inhibitors;

* Adsorption Type; organic compounds that adsorb on metal surface and reduce both anode and cathode reactions.
* Scavengers; react and remove corrosive reagents.

Barrier Methods;

* Paint - can be porous so only reduce, not eliminate, corrosion. So inhibitors are added to the paint, or more reactive metals to act as sacrificial anodes.
* Plastic Coatings - nylon/PTFE/glass are resistant to corrosion.
* Metallic Coatings (Galvanisation) - these should corrode slower than the protected metal. Bimetallic effects should be considered. The coating must be uniform.

Other Methods;

* Robust Design - use thicker walls, good drainage, ensure smooth flows.
* Modify Environment - alter temp., pH, dissolved O_2, relative humidity.

Detecting Corrosion;

* Regular visual inspection.
* Ultrasonic thickness checks.
* Radiography.