An Introduction into Galvanic Corrosion Control of Reinforced Concrete

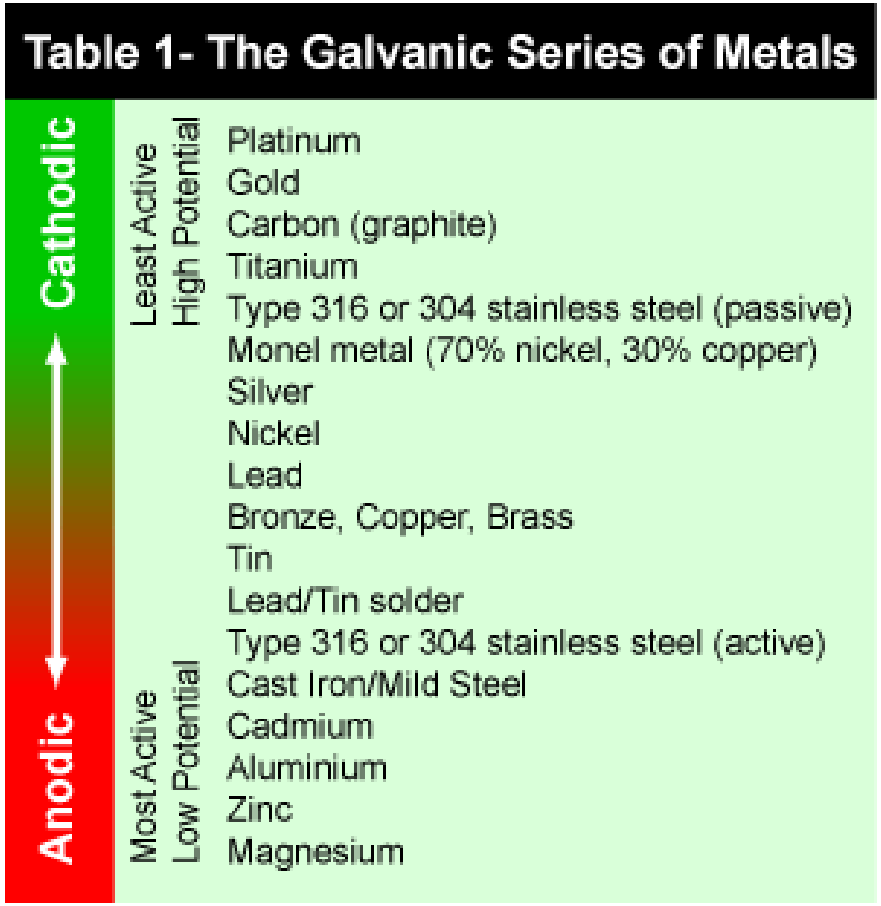
VECTOR CORROSION TECHNOLOGIES

By Dr. George Sergi

The Market

- The use of Galvanic Anodes has continuously grown over the past 15 years
- The choice of systems & types has increased during that time
- No Performance Standard or route to CE marking
- Important that owners & specifier's understand what makes a Galvanic anode work

The Theory



- All metals have different Activities
- We can exploit this natural difference to achieve protection
- Sir Humphrey Davey was the first to commercialise it

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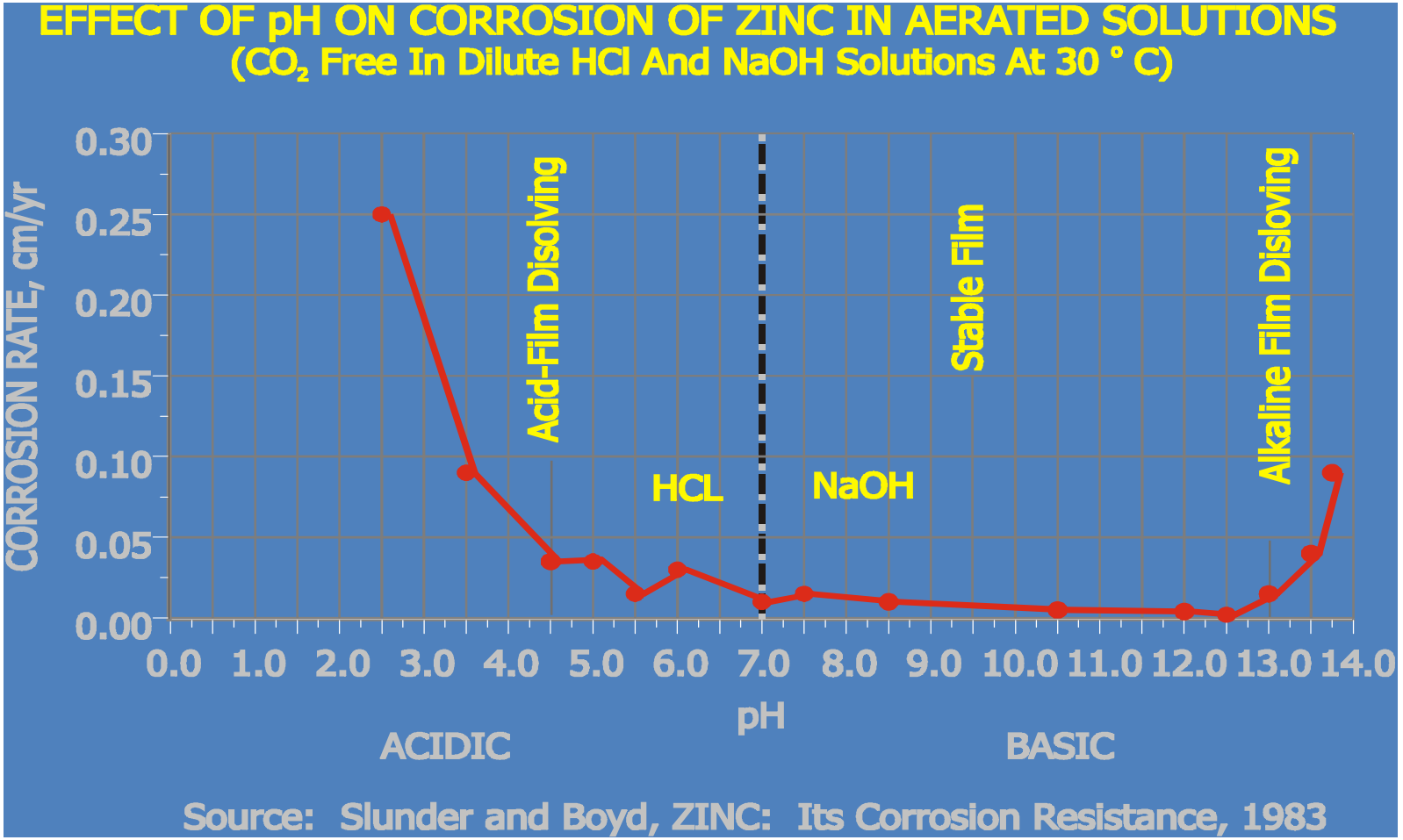
The Problem


EFFECT OF pH ON CORROSION OF ZINC IN AERATED SOLUTIONS
(CO2 Free In Dilute HCl And NaOH Solutions At 30 ° C)
CORROSION RATE, cm/yr
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Acid-Film Disolving
HCL
NaOH
Stable Film
Alkaline Film Disloving
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0
pH
ACIDIC
BASIC
Source: Slunder and Boyd, ZINC: Its Corrosion Resistance, 1983

Activation

- Any Galvanic anode requires an Activator to work long term!!
  - High Alkaline environments
  - Chloride Additives
  - Bromide Additives
  - Sulphates
  - Metal Alloys

Important that you understand which one is used and that you **assess the RISK**

Anode Life & Efficiency

Life Expectancy = (SA, Mass, Efficiency, Utilisation)

- **Surface Area** – Increasing SA increases protection to the steel but reduces life
- **Metal Mass** – Ratio to SA determine life
- **Efficiency** – This varies greatly depending upon the metal and activator used
- **Utilisation** – The amount of metal that can be converted into its Ions

Concrete Applications

- First use in Concrete in 1997
- Use to stop a phenomenon know as:
  - Incipient Anode Formation
  - Ring Anode formation
  - Premature Repair failure
  - Accelerated Repair failure
- All are caused by the same unbalance in electrochemistry

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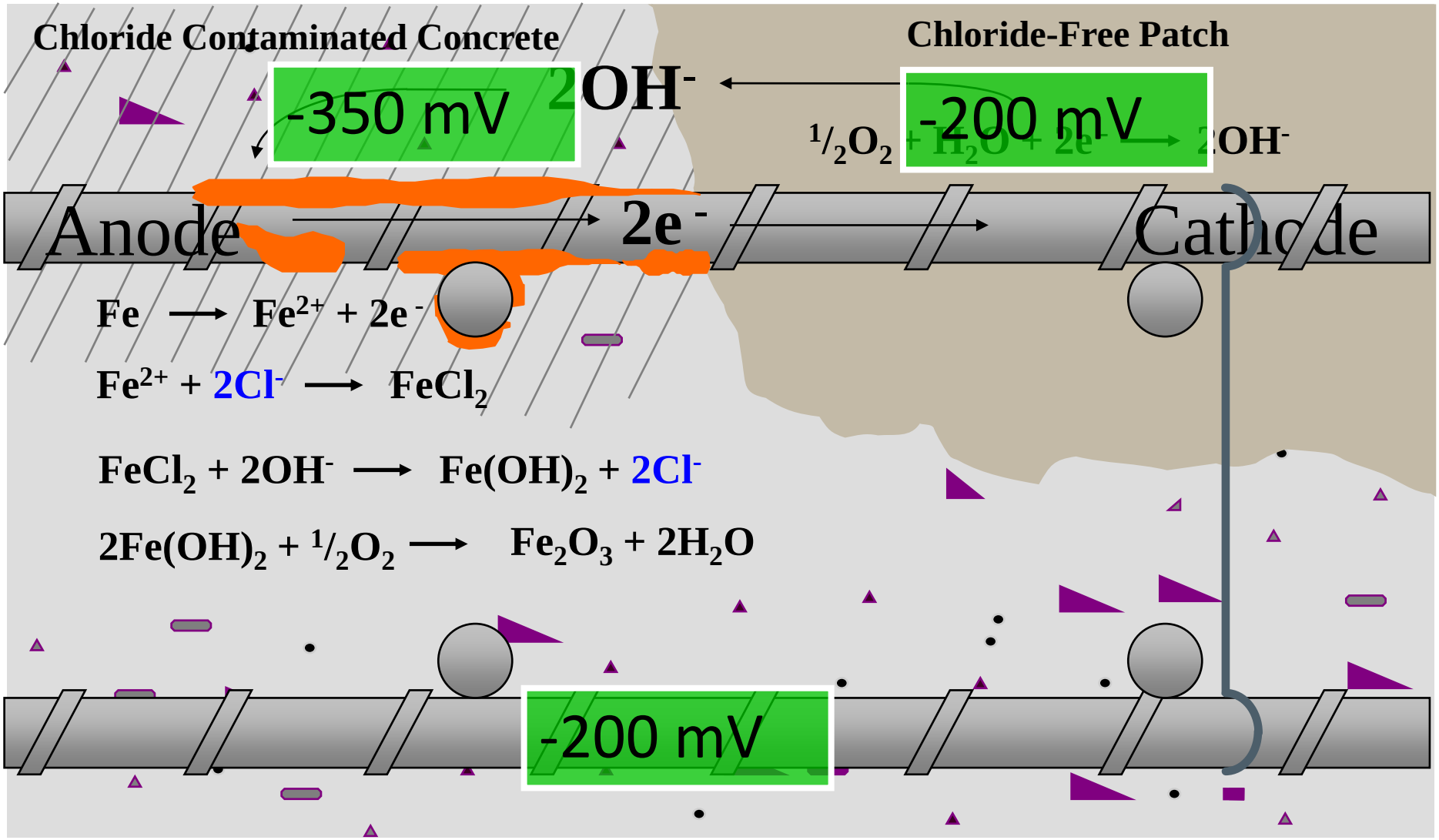
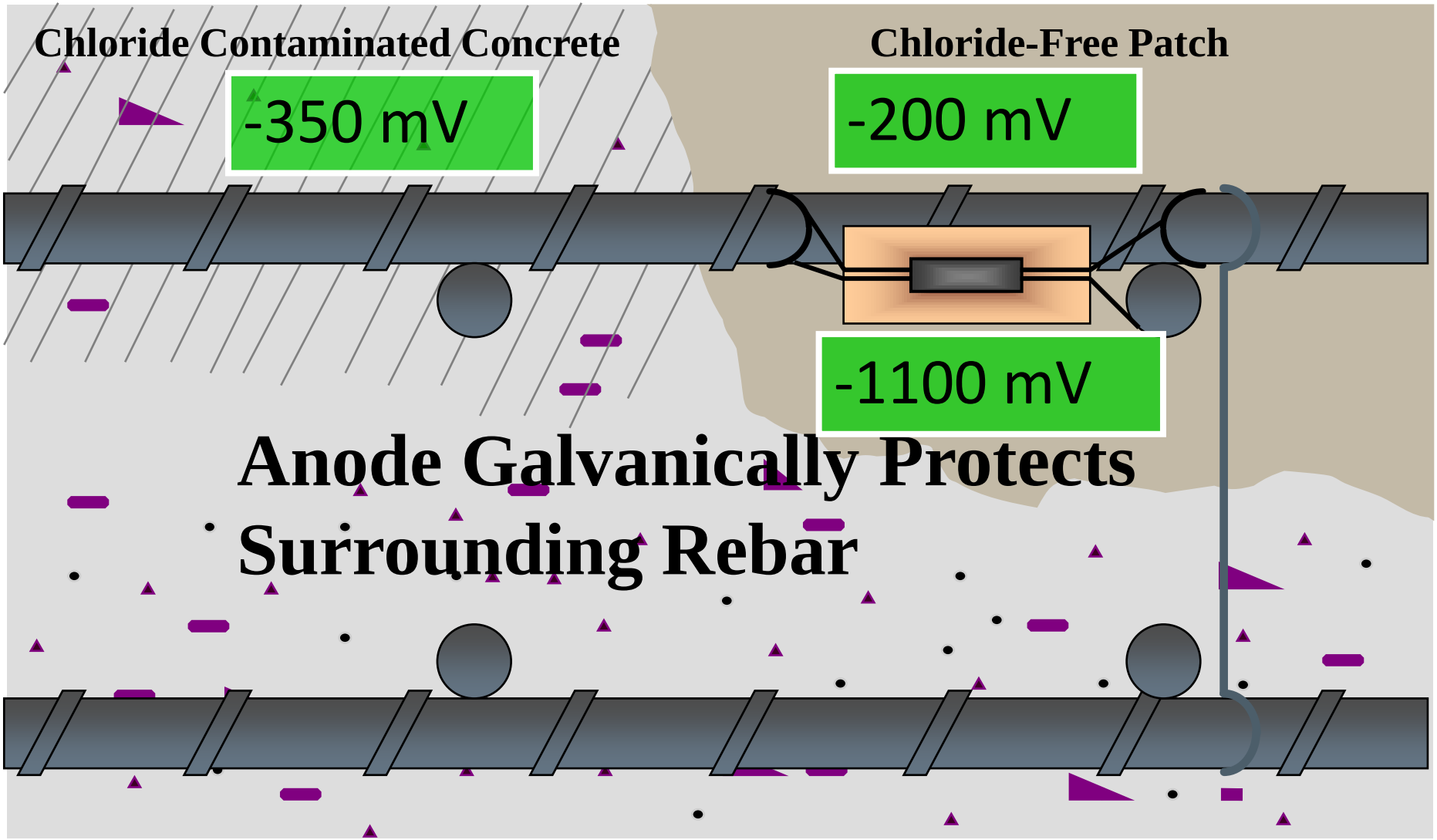
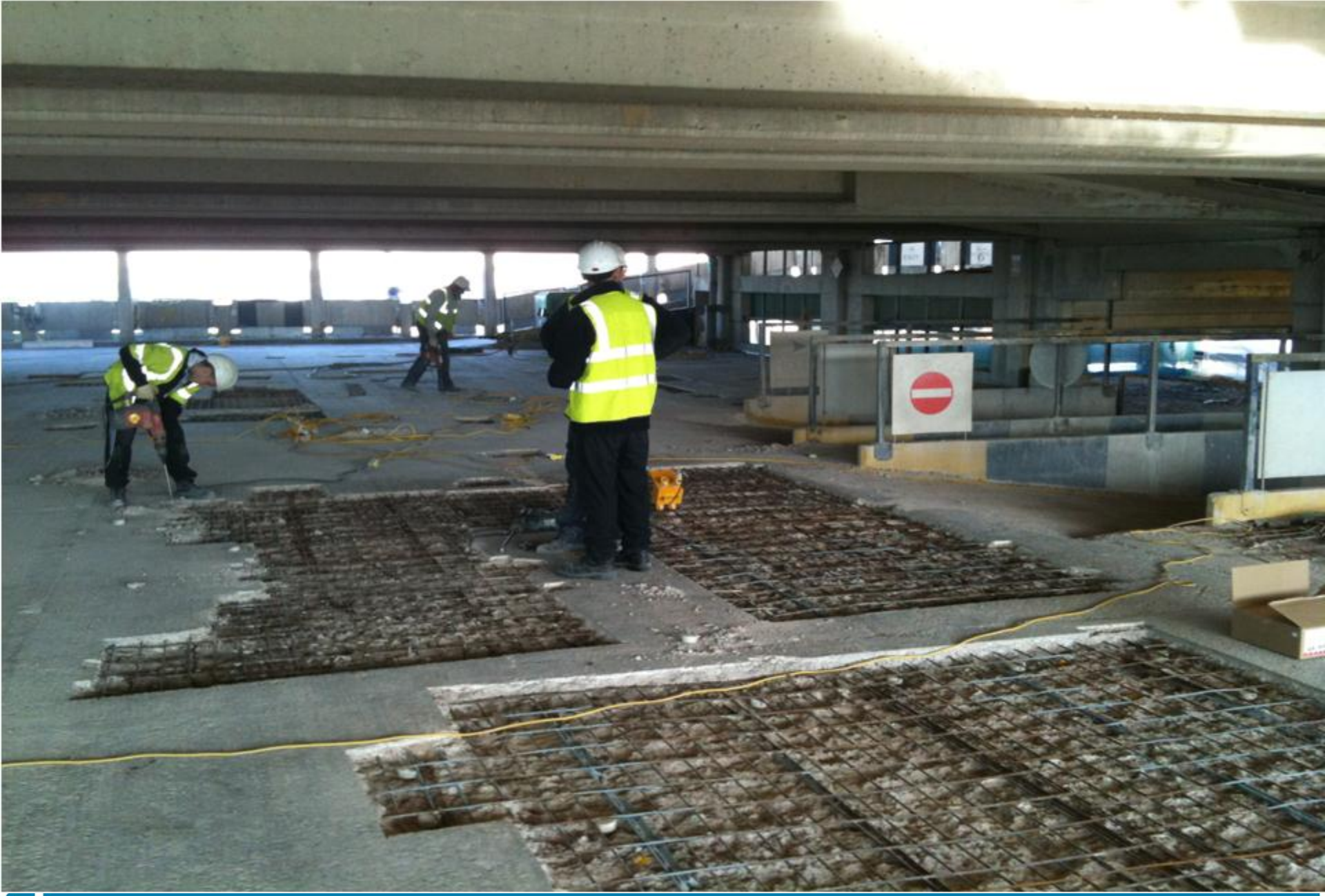

Chloride Contaminated Concrete
Chloride-Free Patch
-350 mV
2OH-
-200 mV
½O2 + H2O + 2e- → 2OH-
Anode
2e -
Cathode
Fe → Fe2+ + 2e -
Fe2+ + 2Cl- → FeCl2
FeCl2 + 2OH- → Fe(OH)2 + 2Cl-
2Fe(OH)2 + ½O2 → Fe2O3 + 2H2O
-200 mV


Chloride Contaminated Concrete
Chloride-Free Patch
-350 mV
-200 mV
-1100 mV
Anode Galvanically Protects Surrounding Rebar

Cathodic Prevention

- Purpose is to prevent corrosion from initiating
- Current density necessary to prevent corrosion from initiating is lower than current necessary to stop on-going corrosion activity
  - Research has shown that 0.25 to 2 mA/m^2 is sufficient to prevent corrosion initiation
- Covered Under ISO BS EN12696:2012


XP4



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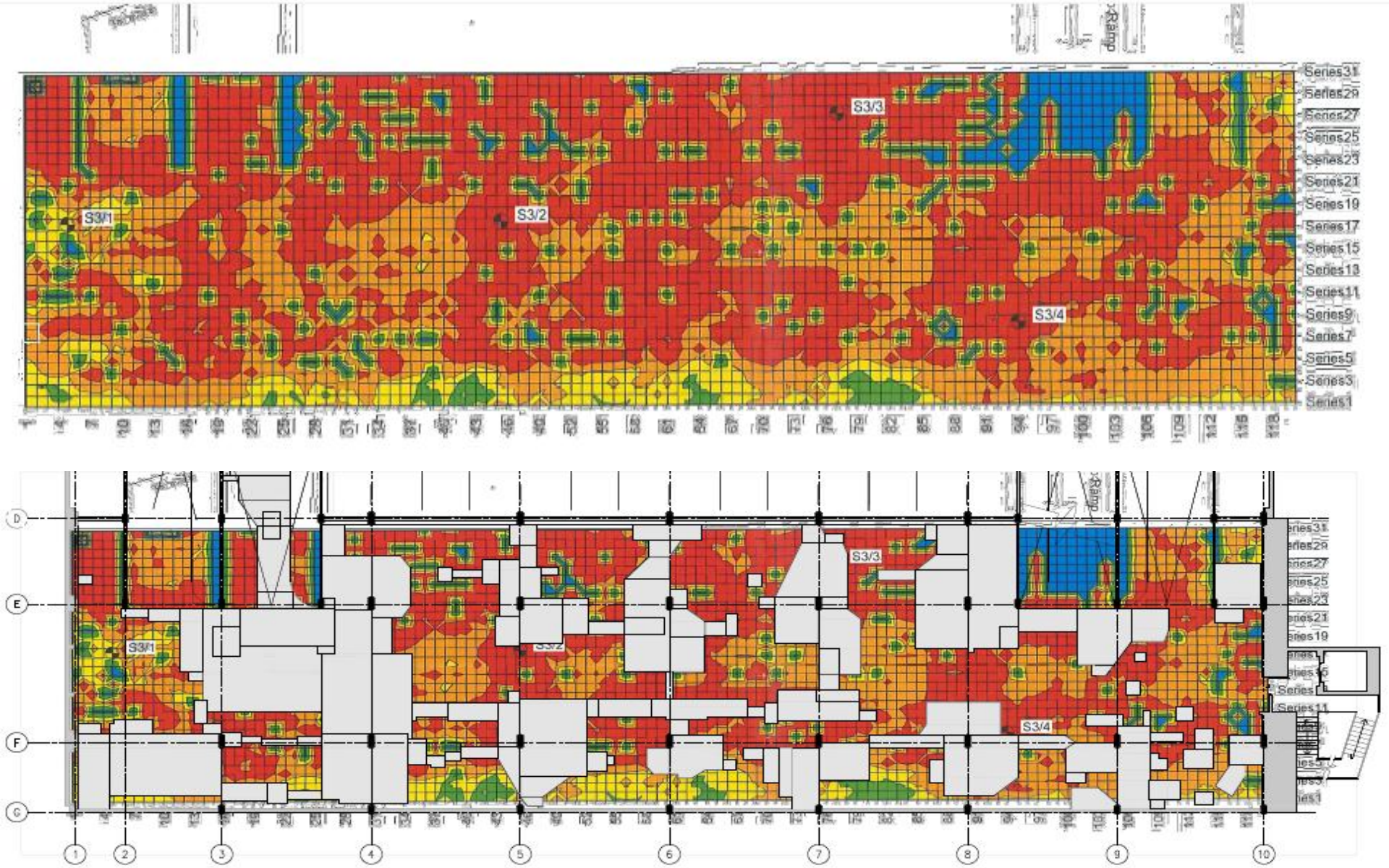
Global Protection

- Protection into areas at risk of Corrosion
  - No visible signs
  - Concrete testing to ascertain risk
- Often distributed over larger areas of concrete
- Typical applied current: 1 to 7 mA/m^2
- Research has shown that as little as 1 mA/m^2 has achieved 96% reduction in delamination growth



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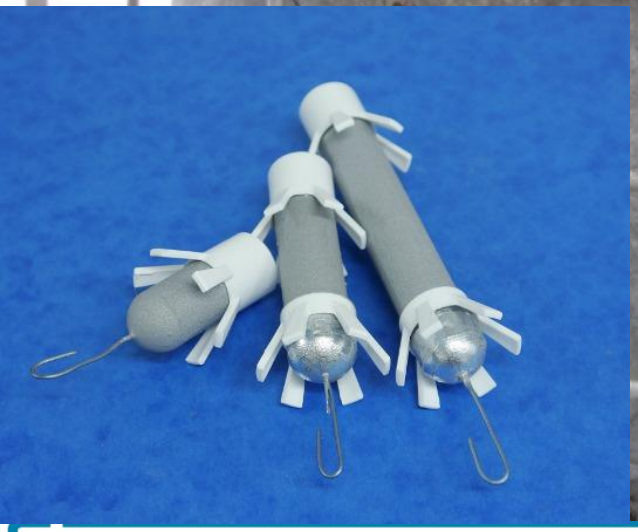

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General Advantages to ICCP

- **Self Regulating** – No requirement for detailed Control.
- **Ease of Installation** – Installation is generally quicker and cheaper than ICCP
- **Cost Effective** – Generally cheaper than ICCP.
- **Monitoring** – Performance can easily be monitored & Life expectancy predicted

Points for Consideration

- **Life Expectancy**– By their nature Galvanic anodes have a finite life (15-25 years max)
- **Control** – It is not possible to continuously control the performance of the system once installed
- **Conformance** – Conformance to ISO BS EN12696:2012 is not guaranteed though is often achieved

Summary

- Design based upon test data – select the most appropriate solution
- Vital that you understand the activation method of the anode used
- Assess the Risk
- Provision in place for monitoring, though this is not required for the performance of the system

Questions

Thank You

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