How?

- Anodes and Cathodes
- Anode loses Metal
- Cathode reacts with oxygen and water
- Electrons in the metal
- Ions in the Electrolyte
Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlement

Summary

How?

Salt Solution

ZINC

COPPER
Steel in Concrete

• Passive Film Protects

• But….
  – Chlorides
  – Carbonation

• Steel Rusts
  – Lose reinforcement

• Rust is bigger than steel

• Bits fall off
Steel in Concrete - Carbonation

Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlement

Summary
Steel in Concrete - Chlorides

Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlement

Summary
Steel in Concrete - Chlorides

Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlemet

Summary

Repaired CATHODE

SALTY and ANODIC

CATHODES

ANODES
**Cathodic Protection**

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<td>Using CP stops rust in any environment</td>
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<td>Chloride contaminated concrete can remain</td>
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<td>Saves</td>
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<tr>
<td>- Propping</td>
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<td>- Access</td>
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**Documents**

- Propping
- Access
- Materials
- Carbon

**Impressed Current or Galvanic**
Cathodic Protection

\[
\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^- \quad \text{(aq.)}
\]
Documents

- BS EN 12696 2000 - CP of concrete
  - Includes criteria
- BS EN 15257 2006 – Certification of CP people
- BA 83 – Highways Agency Advice Note
- TR 36 & 37 – Concrete Society Guidance (Being revised, numbers to change)
Documents

Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlement

Summary

• BS EN 12696:
  – -720mV vs Silver / Silver Chloride / 0.5M Potassium Chloride
  • Or
    – 100mV Decay in 24 hours
  • Or
    – 150mV decay over longer periods
• AND
• No potentials more negative than -900mV for prestressed concrete
Hydrogen Embrittlement

Why?

How?

Steel in Concrete

Cathodic Protection

Documents

Hydrogen Embrittlement

Summary

- If steel is >600MPa UTS
- AND
  - Is under high stress
- AND
  - Is susceptible to it
- AND
  - Hydrogen is being generated
- Risk of hydrogen embrittlement
Hydrogen Embrittlement

- Most cases are self corrosion in very high strength steels
- Simple to avoid in most reinforced concrete
- Don’t turn the system up that high
- We rarely achieve the -720mV
- All the systems I have designed, commissioned or monitored have never come close to -900mV
Summary

• Steel rusts
• For chloride induced corrosion CP saves
  – Carbon Dioxide
  – Repairs
  – Access
  – Propping
• Codes are available
  – Competence of personnel
  – Safe Operation of Systems
• Any Questions???