MARINE STRUCTURES  
CORROSION AND METHODS OF PREVENTION  

CORROSION PREVENTION ASSOCIATION  
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INTRODUCTION

• Corrosion & Accelerated Low Water Corrosion (ALWC)
• Introduction to Cathodic Protection (CP)
• Galvanic Anodes versus Impressed Current
• CP of Steel in Concrete
• Project Examples and Case Study
• Conclusions
CORROSION

- All metals, except Gold, will corrode with time, to try and form a stable oxide compound

- Corrosion rate depends on the metal and its environment.

ACCELERATED LOW WATER CORROSION
ALWC: Background

• Many established forms of localised corrosion, including microbial corrosion

• Since early 1980s increasing reports in UK of corrosion just above LAT

• Quoted range of corrosion rates of 0.3-4.0 mm/ side/ year

• Is it new?

• Influencing Factors?

• 2005 CI RIA report
Identification

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Location

- Sheet Piles
  - In-pans & out-pans
  - Increasingly identified in the band LAT-Mid tide
- U Piles: More prevalent on out-pans?
- Geographic Location
INTRODUCTION

- Humphrey Davy used galvanic anodes in 1824
- Thomas Edison used impressed current in 1890
- Established standards
  - BS EN 13174: 2001
  - DNV RP 401: 2005
- CP well established & proven for steel in sea water
- Mandated for Offshore Installations and Pipelines
- CP of Reinforced Concrete Marine Structures Common

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INTRODUCTION: GALVANIC
INTRODUCTION: IMPRESSED

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GALVANIC OR IMPRESSED CURRENT? - THE CASE FOR GALVANIC ANODES

- No power supplies
- No electricity bill
- No cabling
- Less to go wrong
- Less frequent inspection & monitoring
Galvanic Anodes For Installation to Sheet Piles: Al/ Zn/ In Alloy Most Common
GALVANIC OR IMPRESSED CURRENT? - THE CASE FOR IMPRESSED CURRENT

• Longer anode life
• For new build 50% less capital cost
• Accurate “Instant Off” potentials
• Less anodes to install
• OK if high seawater resistivity
• OK if high bed level (close to mid tide)
GALVANIC OR IMPRESSED CURRENT? - THE CASE FOR IMPRESSED CURRENT
Anodes Durable but Lightweight

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MMO Coated Ti Anode on GRP shield with steel insert
MMO Coated Ti Anode for Tubular Piles
Cabling must run from anodes to T-R
Typical Transformer-Rectifier
DOES IT WORK?
DOES IT WORK?

Visual condition of pile after 3 months

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LIMITATIONS

Top of Pile
High Tide
Mid Tide
Low Tide
Bed Level

Some Protection
Full Protection

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GALVANIC OR IMPRESSED CURRENT? - SUMMARY

- Most UK ports retro-fitting CP use galvanic anodes
- Impressed current used for new ports or extensive upgrading
- Impressed current used in estuarine ports with high water resistivity or shallow water depths
CP OF STEEL IN CONCRETE

- Exposure to seawater, spray will result in chloride ingress, frequently structures are exposed to chloride levels way beyond safe limits.
- Mid-tide to top of splash zone is the best environment for corrosion (Cl⁻ & O₂ present).
- Cathodic Protection systems to stop corrosion of steel in concrete: to prevent this:-
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Example of ‘Incipient Anode’ Effect
CP OF STEEL IN CONCRETE

Impressed Current Systems

Anode types can be:

- Conductive coatings (not suitable for marine conditions)
- Conductive Cementitious Coatings
- Ti Mesh / Sprayed Concrete Overlay
- Discrete Anodes
- Ribbon Anodes

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- Conductive Cementitious Coatings
- Ti Mesh/Sprayed Concrete Overlay
- Ribbed Anodes

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CP FOR NEW STRUCTURES

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CASE STUDY: PROTECTION OF REINFORCED CONCRETE & STEEL

Existing 1960s jetty

- Combination of existing reinforced concrete pile and pre-stressed concrete piles
- Existing steel piles
- New steel piles
- 30-year life extension required
SOUTH HOOK LNG JETTY

ZONE 1

ZONE 2

ZONE 3

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SOUTH HOOK LNG JETTY

Power supply & Monitoring equipment

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CONCLUSIONS

• CP is a useful tool in providing corrosion prevention in marine environments

• There is an extensive track record of using CP to prevent corrosion by ALWC, primarily using galvanic anodes

• Impressed current is used for new build steel piling or for ports in brackish waters

• CP is widely used to prevent reinforcement corrosion, often using impressed current systems, but galvanic systems are increasingly being used