ANODE PERFORMANCE IN SERVICE CASE STUDIES

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  2. Sprayed Zinc & Discrete Probe Anodes

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Galvanic Systems

Key Points

• Primarily Used in USA
• Low Maintenance Requirements
• Various Systems Available
• Pre-Stressed Protection Simplification
Zinc Aluminium Indium Coating

- Completed in August 2003
- 320,000 Sq/ft
- 470 No. Pre-Stressed Beams
- 171 No. Pier Caps

San Luis Pass Galveston Texas USA
Zinc Aluminium Indium Coating

- Initial Current Density
  4.4mA/m² to 6.9mA/m²
- 7 Year Current Density
  0.49mA/m² to 1.27mA/m².
- Minor Defects
- CP Not Compromised
- No Corrosion Found

San Luis Pass Galveston Texas USA
Zinc Mesh Lifejacket & Metalized Zinc

Ketchikan, Alaska USA

- Completed in 2000
- Zinc Coating - Concrete Deck
- Zinc Mesh Lifejacket
  - Pile Caps Splash Zone/Upper Tidal
- Zinc Bulk Anode
  - Underwater Element of Piles
## Zinc Mesh Lifejacket & Metalized Zinc

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Current Density</th>
<th>mA/m²</th>
<th>mA/ft²</th>
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<tbody>
<tr>
<td>Bulk Anodes</td>
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<td>Conventional Reinforced Piles</td>
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<td>Pre-stressed Piles</td>
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<td>Pile Caps</td>
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<td>Thermal Sprayed Zinc</td>
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<td>Precast Conventionally Reinforced Deck</td>
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<td>CIP Conventional Deck</td>
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<td>CIP Conventional Deck w/Prestressed Beams</td>
<td>0.43</td>
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</table>

Initial Current Densities 2000

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Zinc Mesh Lifejacket & Metalized Zinc

- Successful CP
- Low Maintenance Cost
- New Phase II of Works 2010
- No Corrosion Evident

Pilaster Lifejacket™

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Impressed Current Cathodic Protection Systems Key Points

- Controllable Protection
- Monitoring System ALWAYS Installed
- Worldwide Acceptance
- Various Systems
- Long Term Durability
Titanium Mesh & Concrete Overlay

- January 2003
- High Chloride Levels 4.83% by weight of cement
- Three anode zones: Crosshead, Lower Column, Upper Column
- Type 300 Ti Mesh Crosshead
- Type 150 Columns
- 24 Reference Electrodes

Sedbergh Road Interchange Bridge  UK
Titanium Mesh & Concrete Overlay

- Inverted “T” Construction
- Steel/Concrete Area Ratio 5:1
- Protection Designed for Full Depth
Titanium Mesh & Concrete Overlay

Polarisation Assessment Sedburgh Road Interchange
Zone 2 Central Pier

R2 at 900mm Depth

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Titanium Mesh & Concrete Overlay

Depolarisation Assessment Sedburgh Road Interchange
Zone 2 Central Pier

- R2 at 900mm Depth

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Titanium Mesh & Concrete Overlay

- Inverted “T” Construction
- Steel/Concrete Area Ratio 5:1
- Protection Designed for Full Depth
- Operating Current Densities High - Varied between 5.45mA/m² during the first year of operation and is now currently operating at 11.76mA/m²

Seven Year Inspection of Anode System

- There are no reported defects in the anode system during the recent inspection carried out in 2010.
- Proven to be a very durable system based on design requirements and its atmospheric exposure

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Titanium Mesh & Concrete Overlay

Pier Approach Bournemouth UK

- December 2002
- Concrete Surface Area 616.7m²
- Four anode zones
- Anode Type LD25 Ti Mesh
- 8 Reference Electrode
- Marine Exposure
Titanium Mesh & Concrete Overlay

Zone Layout Across Construction Joints
Titanium Mesh & Concrete Overlay

Monthly Depolarisation Results over 2 years Operation

Points above this line indicate a pass at 100 mV BG: EN12696 depolarisation criteria

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Titanium Mesh & Concrete Overlay

- Afforded adequate cathodic protection levels for the past 7 years.
- Current densities varied in the range of 1.45mA/m² during the first year of operation and are now currently operating at 13mA/m².
- No defects in the anode system during the recent inspection carried out in 2010.
- Proven to be a very durable system based on design requirements and marine exposure.

Seven Year Surface Inspection of Overlay

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Sprayed Zinc & Discrete Probe Anode

- January 2003
- 4 Piers Protected
- 12 Anode Zones
- Various Anode Types
- 50 Reference Electrodes
- 32 Temperature & Humidity Sensors

Golden Fleece Cumbria UK
Sprayed Zinc & Discrete Probe Anode

- CP Bearing Shelf/ Beam Ends by discrete anodes
  A. Bearing shelf Ebonex 18mm x 200mm, 86 number
  B. Beam Ends: Side Ebonex 18mm x 100mm, 100 number.
  C. Beam End and Soffit: Ebonex 18mm x 75mm, 32 number
- CP Central pier by sprayed zinc.
- CP to Diaphragm by discrete anodes.
  A. Ebonex Discrete anode 18mm x 100mm, 222 number
- Below ground section protected by tubular titanium ground bed anodes.
  A. Total of 6 anodes at 25mm diameter x 250mm long rated at 2A continuously for 20 years per anode.
Sprayed Zinc & Discrete Probe Anode

A = Probe Anodes
B = Sprayed Zinc
C = Probe Anodes
D = Submerged Anode

Anode Zone layout Golden Fleece
Sprayed Zinc & Discrete Probe Anode

- Sprayed zinc thickness of 400µm - 500µm.
- High purity zinc 99.9%
- Electric arc thermal spray.

- Constant current mode
- Current density of 5mA/m²
- Current density reduced since energising
### Sprayed Zinc & Discrete Probe Anode

<table>
<thead>
<tr>
<th>Zone</th>
<th>mA/m²</th>
<th>Zone</th>
<th>mA/m²</th>
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</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>2.11</td>
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</tbody>
</table>

January 2010 Operating Current Density

- All Zones Requiring Lower Current Densities than at energising
Sprayed Zinc & Discrete Probe Anode

WEST PIER NORTH BRIDGE

TYPICAL ELEVATION ON EAST FACE OF PIER AND DECK DIAPHRAGM

TYPICAL ELEVATION ON WEST FACE OF PIER AND DECK DIAPHRAGM

Screen Shot 1 Monitoring Probe Locations on West Pier North Bridge

Instant Off Zone 5-7
Power Supplies Zones 5-7

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Sprayed Zinc & Discrete Probe Anode

- Zinc De-bondment Found Caused by Low Resistivity Repair Material
- No Loss in Protection from De-bondment.
- No Noticeable Increase in De-bondment on Recent Inspection
- Probe Anode Extremely Effective
- Reduced Current Density Design Avoiding Acidification

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Anode Failures
Key Points

Engineering Design Essential
Product Sale **NOT** Appropriate
Can Be Avoided
Sends Wrong Message for Electrochemical Repair Techniques
Anode Ribbon

- Marine structure
- Tidal Range 20ft
- Anode Ribbon Design
- Column Pile Protection
Anode Ribbon
Anode Ribbon

- Multiple Failures
- Poor Installation
- Low Cover Anode Connection < 5mm
- Major Acidification Due to Current Dumping
- pH of < 5 at Connection points
- Cover > 40mm Connections Good
Surface Applied Zinc Sheet

- Coastal Structure
- Balcony Protection
- Chloride Problem
- Zinc Sheet Design
- Two Types of Covering Used. Tile & Deck Coating

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Surface Applied Zinc Sheet

➢ Failure on Both Surface Finishes

Ceramic Tile

Deck Coating
Surface  Applied Zinc Sheet

- Blistering of Surface Coating
- Jacking of Surface Tiling
- Non Breathable System
- Large Moisture Vapour could not escape
- Product Sale
- Little to No Engineering Carried Out
- Current Mapping Not Understood

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CONCLUSIONS

- A series of critical items need to be addressed when utilising cathodic protection for corrosion related damage.
- Ensure that the anode is suitable for its environment.
- It's capable of being installed correctly.
- And maintained in accordance with international standards.

- Qualified engineers are used for design.
- Qualified installation contractors are used.
- Allow sufficient cost for qualified QA/QC during works.