Cathodic Protection Case Study: Parker Dam Spillway Gates

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Webinar Objectives

• General Cathodic Protection (CP) Design Process
  • What are the steps?
• Parker Dam Spillway Gate CP – Case Study
What is CP?

- Problem: corrosion
- One mitigation method is cathodic protection
  - Galvanic (GACP)
  - Impressed current (ICCP)
- Past Webinars go more in depth on types corrosion and CP

![Schematic of ICCP]
Parker Dam Spillway Gate CP

- Parker Dam, CA (1938)
  - Colorado River, Lake Havasu
  - “Deepest dam in the world”
  - Powerplant- four units: 30,000 kW each

Coated structures and equipment – receiving the most severe exposures
- Spillway Gates (5), Penstock Roller Gates (4), Penstock (4)
- Scroll Case, Turbine Runner, Draft Tube, Etc. (4)
- Trash Rack panels

- Cathodic protection
  - Penstock Gates – GACP (Complete)
  - Spillway Gates – ICCP (In Progress)
Parker Dam Spillway Gate CP

• ICCP for spillway gates
  • Extend service life of coating
  • Provide extra protection for underlying steel
  • ICCP beneficial for large surface area of 50’ x 50’ gates

• Parker Dam staff will install
• Reclamation Materials and Corrosion Lab – CP design & installation support
CP System Design Process

1. Contact us
2. What are your needs?
3. Project Management Plan
4. Design Data
5. CP Design

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Project Management Plan
Project Management Plan

- Contacts
- Objectives
- Scope/tasks
- Schedule

- Budget
- Roles & responsibilities
- Risk management

<table>
<thead>
<tr>
<th>Project Management Plan (PMP)</th>
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<tbody>
<tr>
<td>Job Title: Parker Dam Spillway Gate CP</td>
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<tr>
<td>Accounting String (Fund and WBS):</td>
</tr>
<tr>
<td>Project Manager (Team Leader) (name/code/telephone/email): Jessica Torrey, 86-68540, 303-445-2376, <a href="mailto:jtorrey@usbr.gov">jtorrey@usbr.gov</a></td>
</tr>
</tbody>
</table>
Design Data
Design Data

- Structure dimensions
- Operation
- Drawings/photos
- Water quality data
- Soil samples
- Dissimilar metals
- Electrical isolation
- Coating condition
- Availability of power

Parker Dam Spillway Gates

Design Data:

- Gate Size: 50 ft x 50 ft
- Riveted Construction
- Slide Gate Style (Stoney)
- Water line ~3-5 ft from top of gate
- Mudline ~2 ft from bottom of gate
- Water Specific Conductance (2008-2010) = 1000 μS/cm
Dec 1 2014

Surface 0.418V vs C
5ft 0.410V
10ft 0.403V
20ft 0.398V
30ft 0.397V

Flow East (d1-5 E to W) towards trashracks

Gate 5

more rusting of rivets – maybe due to higher flow at this gate
Rust nodules by rivets on bottom section of Gate #5
CP System Design
CP System Design

• Determine metal surface area
  • Each gate ~6600 rivets; add ~120 sq. ft. (~5%)

<table>
<thead>
<tr>
<th>Component Name</th>
<th>SA (ft²)</th>
<th>SA (m²)</th>
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<tbody>
<tr>
<td>upstream skinplate</td>
<td>2500</td>
<td>232</td>
</tr>
<tr>
<td>rivets flat SA</td>
<td>175</td>
<td>16</td>
</tr>
<tr>
<td>rivets dome SA</td>
<td>298</td>
<td>28</td>
</tr>
<tr>
<td>skinplate minus rivet flat</td>
<td>2325</td>
<td>216</td>
</tr>
<tr>
<td>skinplate w/ dome rivets</td>
<td>2622.5</td>
<td>243.6</td>
</tr>
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</table>
CP System Design (cont.)

- Rectifier current requirement
- Current distribution calculations
  For steel:
  - Achieve $-0.850 \, V_{\text{CSE}}$
  - No more negative than $-1.100 \, V_{\text{CSE}}$
- Anode selection and cable sizes

<table>
<thead>
<tr>
<th>Safety Factor</th>
<th>Anode Style</th>
<th>$I_p$ (max design current for all structures)</th>
<th>$L_{\text{linear}}$ (Length of exposed area)</th>
<th>$w$ (width of exposed area or diameter)</th>
<th>$S_{\text{A,anode}}$ (exposed surface area of anode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 1.152</td>
<td>2.5/50</td>
<td>20 0.500</td>
<td>1.000 0.025</td>
<td>60.5 0.039</td>
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<tr>
<td>2.0 1.152</td>
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<td>24 0.610</td>
<td>0.750 0.019</td>
<td>56.5 0.036</td>
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<td>4C/FW20YR</td>
<td>24 0.610</td>
<td>0.750 0.019</td>
<td>56.5 0.036</td>
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</tbody>
</table>
Anode mounting design

- Feasibility:
  Anodes hanging from suspended wire system

- Final:
  Slotted PVC mounted to concrete piers
CP System Design (cont.)

- Conduit size & path – diam. based on # of cables
CP Installation Upcoming

• Dates TBD
  • Delays during Summer 2020
due to COVID circumstances

• Trip #1: installation and initialization

• Trip #2: monitoring and training
Conclusions

• CP design process – case by case

• Work with client
  • Challenges and design changes
Acknowledgements

• John Steffen and Parker Dam staff
• TSC Materials and Corrosion Laboratory (8540), Plant Structures (8120), and Concrete & Structural Laboratory (8530)
Thank you!

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Cathodic Protection Case Study: Mni Wiconi Core Pipeline

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Cathodic Protection of Pipelines

Webinar Objectives:

• Review of Field Data Collection Procedures

• Data Analysis
CP System Evaluation Process

1. Contact us
2. What are your needs?
   a) Testing
   b) Inspection
   c) Repair services
   d) Training
3. What we need from client
   a) Scope of work or problem
   b) Photos
   c) Historical data
   d) Drawings
4. Final products
   a) Report including data, photos, observation, and recommendations/conclusions
      i. Some system repairs may be performed during the survey
   b) SOP for testing CP system

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Mni Wiconi Core Pipeline - CP

- **Mni Wiconi Core Pipeline**
  - Delivers water from the Missouri River west to Kadoka, SD
  - Provides water to over 39,000 people
  - ~123 miles of mostly 26-in diameter welded steel pipe
  - ~94 miles of PVC pipeline

- **Cathodic protection**
  - Welded Steel Pipeline – ICCP
    - 10 Rectifiers approximately evenly spaced
    - Over 300 test stations
  - PVC pipeline – GACP
    - Zinc anodes on metallic fittings

- **System testing**
  - MCL was approached to evaluate the CP system in 2014.
  - The system had not been tested in several years.
Mni Wiconi CP System Testing

• MCL was approached to evaluate the CP system in 2014.
  • The system had not been tested in several years and data should be reviewed by MCL personnel approximately every 5 years.
• Annual testing is crucial to ensure the system is both operational and provides adequate protection.
• Utilizing Reclamation resources was desirable in this situation to avoid additional costs by contracting the work out.
CP System Testing
Rectifier Data Collected

- Data collected during the survey is crucial to determine the efficiency of a system.
- Rectifier Data needs include:
  - Condition (broken wires, vegetation overgrowth, insect infestation)
  - Rectifier information (rating, model, style, etc.)
  - Tap settings
  - Voltage output using meters and portable voltmeter
  - Current output using meters and portable voltmeter
  - Current output of anodes using portable voltmeter if possible
Test Station Data Collected

• Data collected during the survey is utilized to determine the efficiency of a system.
• Test stations are a crucial component for performing these types of surveys.
• Test Station Data needs include:
  • Condition (broken wires, vegetation overgrowth, insect infestation)
  • Uncorrected potential (“on” potential with system energized)
  • Polarized potential (“instant-off” potential with system interrupted)
  • Anode current output for galvanic anode systems
  • GPS coordinates and other identifying features
Data Collection Requirements

- To perform the survey the system must be interrupted briefly. This can be performed in the following manner:
  - Disconnecting the anode cable from the structure cable at the shunt for GACP systems.
  - Installing an interrupter in the output circuit of a rectifier for ICCP systems.

- Typical interruption cycle is 7 seconds on and 3 seconds off.
  - Newer data loggers can measure a faster interruption cycle.
  - It is critical to interrupt rectifiers at the same time for systems with multiple rectifiers.

- A previous webinar was given on how to test a cathodic protection system and is available.
Review and Analysis of Collected Data
Data Analysis - ICCP

- Utilizing programs such as Excel, Origin, or equivalent program.
- Upload or input the collected data.
- Data may look like the figure below depending on the method or collection.
Data Analysis - ICCP

• On/Instant-Off potential data is then plotted versus location as shown and problem areas such as off or polarized potentials below the $-850 \text{ mV}_{\text{CSE}}$ criteria can be identified.

• The $-100 \text{ mV}$ of polarization can be used in this case due to historical data.

• Data indicates the following:
  • A difference between an on potential and an instant-off or polarized potential.
  • On potentials or uncorrected potentials are not indicators of adequate protection.

Note: "Instant-Off" pipe-to-soil potential at each test station (red line) should be equal to $-0.850 \text{ V (CSE)}$ or more negative. (NACE SP0169)
Data Analysis - ICCP

• Data can be separated by test station or location and the critical information such as the polarized potentials as shown.

• Not all test stations may be tested every year due to the condition of the test station, broken wires, access, etc.

• This is not an issue when looking at the overall system.

• It is ideal to locate them and test them each year if possible.

Inaccessible due to flooding
Data Analysis - ICCP

- Data plotted for multiple years aids in determining any trends in the readings.
  - Effect of rectifier output changes.
  - Effect of a wet or dry season.
  - Which test stations were not tested and how often.
    - Gaps indicate missing, broken, or untested test stations.
    - Significant spikes could indicate a bad measurement, poor cable connection at the pipe.

- Data indicates the following:
  - Locations with polarized potentials between -850 mV$_{\text{CSE}}$ and -1100 mV$_{\text{CSE}}$ are adequately protected.
  - The polarized potential at TS238 is close to the native potential and a change in values was not observed during the interruption cycle.
Conclusions - ICCP

• The low polarized potentials observed at the beginning of the pipeline were low due to broken bond cables discovered in a vault.
  • Cables were reattached and the next annual survey should indicate higher polarized potential readings.

• The rectifier output should be increased, and the location monitored or investigated at locations with polarized potentials more positive than $-800 \text{ mV}_{\text{CSE}}$.

• The rectifier output should be reduced where polarized potentials are more negative than $-1100 \text{ mV}_{\text{CSE}}$.

• TS238 should be investigated for a possible short to steel in concrete or other issue.
Data Analysis - GACP

- Galvanic anode cathodic protection data collected on non-metallic pipe is shown in the graph.

- Data plotted for multiple years aids in determining if an anode is nearing its life and when to replace.

- Data indicated the following:
  - Most locations were adequately protected in accordance with the \(-0.850\, V_{\text{CSE}}\) criteria.
  - TS338 and TS340 indicate inadequate protection.
Conclusions - GACP

• It is recommended that the anodes at TS338 and TS340 be replaced as soon as possible.

• All locations should be closely monitored yearly due to the anode replacement required at the test stations.
Thank you!

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