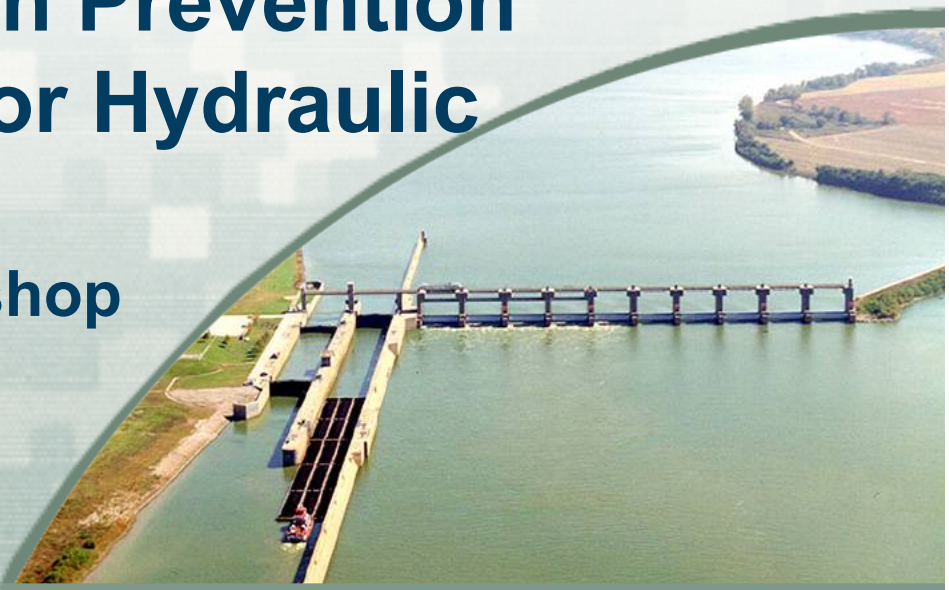
ERDC
Engineer Research and Development Center

Monitoring of Corrosion Prevention and Control Systems for Hydraulic Steel Structures

2014 Lock Maintenance Workshop



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US Army Corps of Engineers®

Monitoring of CPC Systems for Hydraulic Steel Structures Background

- Methods are needed to constantly monitor corrosion prevention and control systems for the detection and prediction of degraded conditions.
  - Steel structures are a major component of marine transportation systems and floodwalls, and are critical components of dams.
    - Steel is one of the strongest materials, is relatively inexpensive, can be formed or worked into almost any shape, and is easy to work with.
    - Carbon steel is the most used steel on locks and dams and are referred to by the Corps of Engineers as Hydraulic Steel Structures (HSS). (Because of the size of these structures, the cost of other steel alloys is prohibitive.)
    - The major limitation of carbon steels is corrosion.

New Cumberland Locks and Dam, Stratton OH

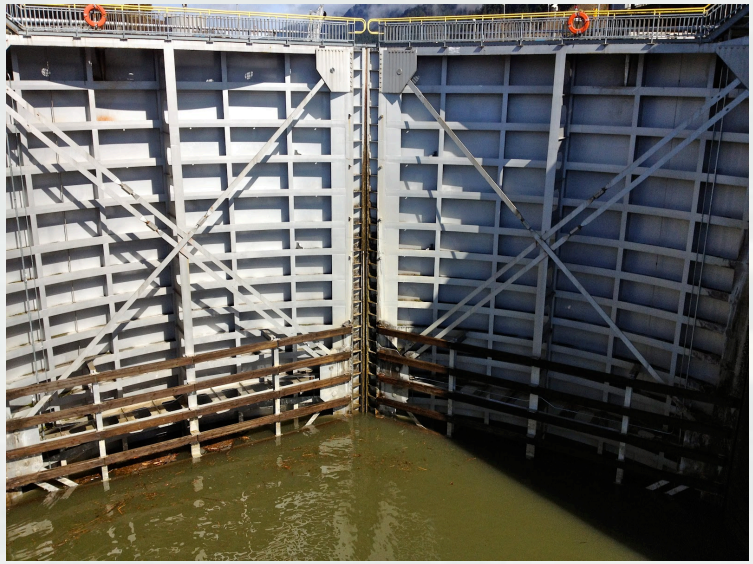
Monitoring of CPC Systems for Hydraulic Steel Structures Background

- Methods are needed to constantly monitor corrosion prevention and control systems for the detection and prediction of degraded conditions.
  - Many districts are able to conduct yearly inspections of cathodic protection (CP) systems, but this will decrease as budgets and personnel decrease.
  - Major inspections and repairs at HSSs are conducted only every five to six years as dewatering is costly and has a major impact on navigation.

Hannibal Locks and Dam, Hannibal OH

Monitoring of CPC Systems for Hydraulic Steel Structures Background

- Current density of cathodic protection systems is non-uniform on miter gates due to fatigue cracking.
- Repairs and upgrades could unintentionally change the current density or distribution of cathodic protection systems that are already in place.
- Commonly used design life for cathodic protection systems and coatings is 20 years. Systems will require increased monitoring when nearing their design life.



Bonneville Lock and Dam, Cascade Locks OR

Monitoring of CPC Systems for Hydraulic Steel Structures Background

- The primary method for corrosion detection is visual.
  - But by the time corrosion is visible, it's too late.
    - "… fracture critical members to be inspected every five years and that all HSS be inspected not to exceed 25 years, even if dewatering is required."
    - "HSS should be included as part of the periodic inspection program. It shall consist of sufficient observations to determine the physical and functional condition of the HSS, to note any changes from previously recorded conditions, to identify any changes in loading or use, to identify any developing problems, and to ensure that the structure continues to satisfy service requirements."
- The preferred method for CPS monitoring is analytic.
    - "The voltage and current readings of the rectifiers should be observed, monitored, and recorded daily."
    - "The evaluation of annual reference cell voltage data indicating the structure-to-electrolyte (lock-to-water) potential is the accepted method for determining the adequacy of corrosion protection provided by the CPS."

Monitoring of CPC Systems for Hydraulic Steel Structures Objective

- We will *improve corrosion detection and monitoring systems* of critical Civil Works Structures through a better understanding of
  - the corrosion mechanisms
  - the interaction of protective coatings with the structure
  - the interaction of the monitoring systems with the coating and structure, and
  - the detection and monitoring technologies themselves.
- The goal is not to detect corrosion, it is to detect deficiencies in the corrosion prevention and control systems.

Locks and Dam 27, Granite City IL

Monitoring of CPC Systems for Hydraulic Steel Structures Approach

- Operational Evaluation
  - Identify Critical Monitoring Needs
  - Verify Monitoring and Information Needs Via a Field PDT
  - Environmental and Operational Assessment
- Corrosion R&D
  - Protective Coatings
  - Effect of Coating Breakdown / Defects on Localized Corrosion
  - Corrosion Issues with Coatings and Other Corrosion-Critical Elements
  - Effect of Coating Defects on Impressed Current Cathodic Protection
  - Studies of ERDC and District Corrosion Prevention, Control, Detection, and Monitoring Technologies

Monitoring of CPC Systems for Hydraulic Steel Structures Approach

- Data Acquisition
  - Identify Monitoring Sensor Types and Locations
  - Architect Data Acquisition, Transmission, and Archival
- Analytic Techniques for Corrosion Potential Analysis
- Pilot Site Demonstration
  - Identification of Pilot Site
  - Pilot Site Installation
  - Pilot Demonstration
- User Documentation
- Training

Locks and Dam 15, Rock Island IL

Monitoring of CPC Systems for Hydraulic Steel Structures Benefits

- Benefits
  - Improved corrosion engineering-based knowledge of the current conditions of corrosion prevention and control systems
  - More cost effective management of MTS assets and attendant economic benefit for bulk transport
  - Improved reliability of Impressed Current Systems through introduction of more robust and durable systems more adequately designed for the operating environment
- Payoffs
  - Application appropriate corrosion prevention and control systems
  - Extended life of HSS corrosion prevention and control systems
  - Reduced maintenance and repair costs

LaGrange Lock Gates, Versailles IL

Monitoring of CPC Systems for Hydraulic Steel Structures Users

- Government
  - Corps of Engineers
  - Bureau of Reclamation
  - Civilian transportation system
  - Civilian population
- Engineers and Managers
  - District Engineers
  - Asset Managers
  - Budget Managers

Thomas J. O'Brien Lock and Dam, Chicago IL

Monitoring of CPC Systems for Hydraulic Steel Structures Collaborators

- ERDC Principal Investigators

  Michael McInerney (Electronics Engineer) – Project Manager

  Susan Drozdz (Chemist)
  Richard Haskins (Electronics Engineer)
  Robert Moser (Corrosion Engineer)
  Bruce Barker (Electronics Engineer)
  Charles Marsh (Materials Engineer)
  Brian Tetreault (Software Engineer)

- PDT Collaborators

  Wynne Fuller (CESAM-OP) – Advisor

  Jeffrey Stamper (USACE Inland Navigation Design Center (INDC)) – Advisor

  Travis Adams (Welding and Metallurgy TCX) – Consultant

  Michael Wallace (Corrosion Control and Cathodic Protection Systems DX) – Consultant

  Jessica Torrey (Bureau of Reclamation - Technical Service Center) – Consultant

  Thomas Tehada (NAVFAC-ESC) – Consultant

New Orleans Industrial Canal

Monitoring of CPC Systems for Hydraulic Steel Structures Field Survey

Please answer the questions for as many components as you are able. A single structure may have multiple metal components protected by several coatings or cathodic protection systems. Provide as much detail as possible.

Each component should have its own tab. For each additional component make a copy of the tab, and begin again.

1) WHAT IS THE NAME OF THE COMPONENT? (E.G. GATE, VALVE, ETC.)?
2) WHAT TYPE OF STRUCTURE? (E.G. LOCK, DAM, ETC.)?
3) DESCRIBE THE COMPONENT. (E.G. LOCATION, SIZE, MATERIAL, ETC.)?
4) IS THERE CORROSION PRESENT? IF SO, PLEASE DESCRIBE THE EXTENT.
5) IS THERE A CORROSION PROTECTION SYSTEM PRESENT? IF SO, PLEASE DESCRIBE. (E.G. COATING, IMPRESSED CURRENT, SACRIFICIAL ANODE, ETC.) IS THERE MORE THAN ONE TYPE OF CORROSION PROTECTION SYSTEM?

Monitoring of CPC Systems for Hydraulic Steel Structures Field Survey

6) IS THERE ANY REGULAR MAINTENANCE OR INSPECTION OF THE COMPONENT? IF SO, HOW OFTEN IS IT INSPECTED? DESCRIBE THE MAINTENANCE PERFORMED.

7) IF THERE IS A CORROSION PROTECTION SYSTEM PRESENT, IS THERE ANY MAINTENANCE OR INSPECTION SPECIFIC TO THE SYSTEM? IF SO, HOW OFTEN IS IT INSPECTED? DESCRIBE THE MAINTENANCE PERFORMED.

8) IF KNOWN, WHAT IS THE EXPECTED LIFE (IN YEARS) OF THE CORROSION PROTECTION SYSTEM? FROM EXPERIENCE, WHAT IS THE ACTUAL LIFE (IN YEARS) OF THE CORROSION PROTECTION SYSTEM?

9) ARE THERE ANY OTHER PROBLEMS OR CONCERNS REGARDING THIS COMPONENT, OR ITS CORROSION PROTECTION SYSTEM?

QUESTIONS

Ice Clearing Winter 2014, Pittsburgh PA