RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

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Bottom Line

This research project assessed electrochemical impedance spectroscopy (EIS) as an evaluation tool to determine service life for protective coatings on Reclamation structures, particularly those in the harshest and most inaccessible service environments. This research developed the field method for quantitative coating inspections.

Better, Faster, Cheaper

EIS allows for laboratory and field evaluation of coating performance. The quantitative field inspection method augments visual inspection and non-destructively measures coating performance. This information improves a facility owner's ability to plan for coating maintenance and maximize its service life.

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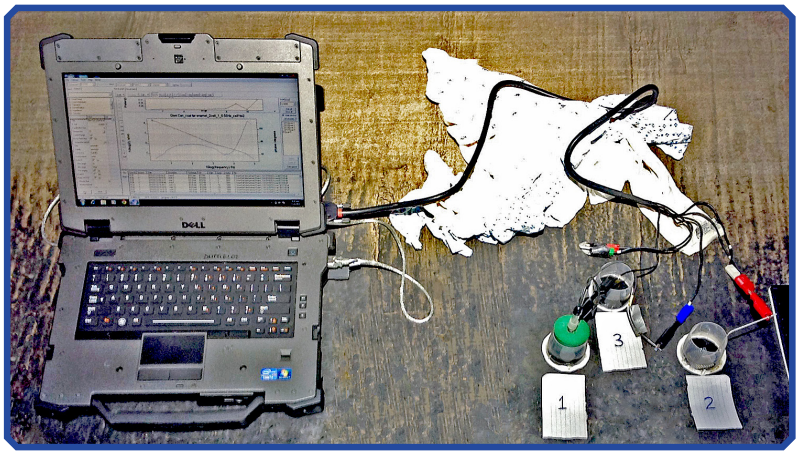
Electrochemical Impedance Spectroscopy Coating Evaluation

A new tool to augment traditional coating inspections on Reclamation structures

Problem

The annual cost of corrosion prevention and control systems for steel structures has greatly increased in recent decades and is estimated to be 3.1 percent of the gross domestic product in the United States. Coatings help protect metallic structures from corrosion. Extending the service life of coatings is key in helping to control these costs. Reclamation's experience with epoxy-based coatings, for example, shows they provide 15 to 25 years before requiring a full recoat. A coating system that is in good condition protects against corrosion, which decreases equipment's efficiency and reliability. Reclamation needs effective ways to measure and predict the useful service life of its coatings to improve planning for coatings maintenance and preserve its infrastructure.

Laboratory testing methods need to be translated into the field to inspect coatings on existing infrastructure. To obtain reliable data consistently, Reclamation needs a field inspection method that is fast and easy to use.



Measuring coating performance on the inside of a penstock at Glen Canyon Powerplant, Arizona.

Solution

This Reclamation Science and Technology Program research project converted the laboratory Electrochemical Impedance Spectroscopy (EIS) technique into a ruggedized field inspection tool using existing laboratory data for benchmarking during these field coating systems evaluations. EIS, an alternating current impedance method, applies a small voltage to measure the complex resistance of dielectric materials such as protective coatings.

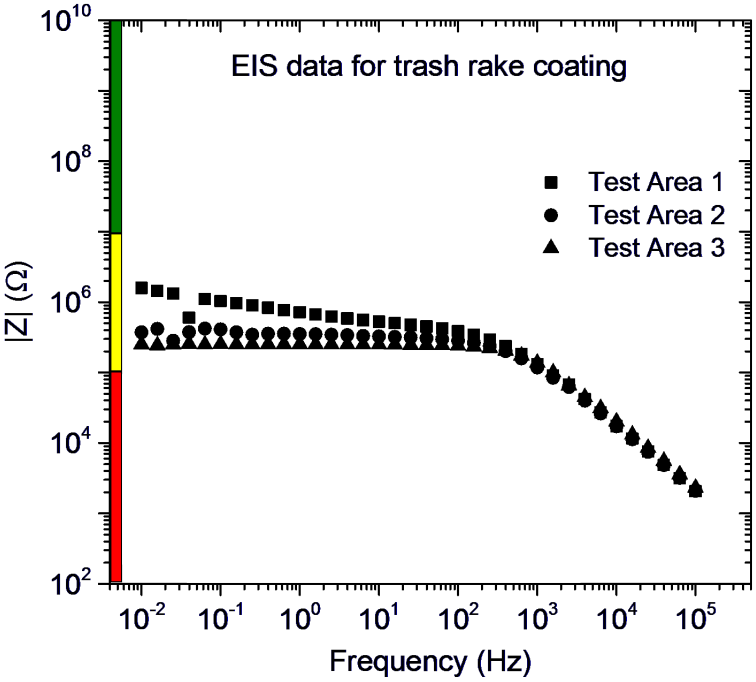
The coatings laboratory in Reclamation's Technical Service Center (TSC) has been evaluating commercial protective coatings used on its structures for nearly 10 years through simulated weathering and periodic EIS tests. The evaluation protective coatings on steel substrates during natural or accelerated weathering in a laboratory is the primary use of EIS in coatings science. Accelerated weathering techniques decrease the amount of time needed to cause the protective coatings to fail. Together, laboratory EIS testing and accelerated weathering provide a truncated, quantitative method for evaluating the loss of a coating material's protective properties.

Application and Results

Researchers identified laboratory data trends that indicated material degradation (i.e., loss of the coatings protective performance). These data are a starting point for inspectors to interpret field EIS data and quantitatively describe the coating condition to owners to help estimate the remaining service life.

Laboratory experiments demonstrated that laboratory reference data provides a good comparison tool to measurements of the same coating in the field and that results are accurate.

The field EIS method is available for testing on in-service structures. A simplified process for data interpretation is given using color coding of the coating condition by green-yellow-red as good-moderate-poor, respectively. The color coding in the displayed graph is specific to atmospheric service. This coating should be scheduled for replacement before the low frequency data enters the red region.



EIS field test results for coating with no visible defect.

One example demonstrates the potential usefulness of this EIS field testing method. After the gates were recoated at Parker Dam, California, they were placed back into service. When they were removed several weeks later to readjust the gate seals, extensive rust staining was noted on the newly recoated gates. An investigation of the recoating work ensued, including the field EIS testing. Comparing the EIS field data to existing laboratory data indicated that the coating applied to the penstock gates did not provide the desired corrosion protection. The EIS field data suggests the coating film had inherent defects at the time of application and product cure, which was not apparent from visual inspections.

Other demonstrations of the EIS field test indicated that the test does provide useful, consistent results and is easy to apply in the field.

Future Plans

This research demonstrated field viability for EIS testing of protective coatings on Reclamation structures. Reclamation is working with manufacturers of the EIS testing equipment to continue to improve its field readiness and to lower instrument costs.

The TSC will continue to use this testing method to evaluate coating performance and estimate remaining coating service life for facility owners.

"This research project helped to develop a field method to measure remaining service life of an existing coating at Reclamation facilities. This information can be used by facility owners when planning coating maintenance to maximize he useful life of the coating."

Bobbi Jo Merten
Chemist
Reclamation's Technical Service Center

Collaborators

Reclamation's Grand Coulee Powerplant, John W. Keys Pump-Generating Plant, Little Oso Dam, Parker Powerplant, and Glen Canyon Powerplant

- **U.S. Army Corps of Engineers (USACE), Construction Engineering Research Laboratory**
- **USACE's Ozark-Jetta Taylor and Wilbur D. Mills Lock and Dams**
- **Denver Water's Marston Dam**

More Information

www.usbr.gov/research/projects/detail.cfm?id=7673

Merten, B., S. Drozdz, C. Gills, D. Tordonato, and J. Ryan. 2015. "Methodology for coated infrastructure inspection by mobile potentiostat." Conference Proceedings for the Society for Protective Coatings, Las Vegas, Nevada, February 2015.

For printable version see: www.usbr.gov/research/docs/updates/2016-18-eis-coatingevaluation.pdf