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Field Validation of Impedance Spectroscopy Coating Assessments

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This research study found good agreement between electrochemical impedance spectroscopy performed in the field and laboratory, indicating efficacy as a qualitative analysis tool for coated structures in the field.

Mission Issue

Traditional coating assessments are qualitative and do not provide sufficient information to estimate a coating's condition or remaining service life.

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Problem

The process to determine the quality of coatings on Reclamation structures has been evolving to allow for a more complete picture when planning maintenance. Traditional methods to determine the remaining service life of a coating include qualitative, visual assessments. Visual inspection identifies only those areas of the coatings that are visually damaged and provides no information for the rest of the coating. Evaluating undamaged areas of the coatings could help Reclamation to better plan the timing and approach for coating maintenance and lower overall costs.

Technical Service Center coating specialists evaluated electrochemical impedance spectroscopy (EIS) as a method to quantitatively evaluate existing coatings on Reclamation structures. The goal of this study was to further the validity and usefulness of field EIS testing through laboratory and field experiments.

Figure 1. Electrochemical impedance spectroscopy test cell set-up for coating evaluation near pipe crown in a large diameter pipe.

"Field EIS has already changed the way Reclamation engineers perform coating inspections—this work has validated the method as an important and useful technique that could be adopted industry-wide."

Stephanie Prochaska,
Materials Engineer
Bureau of Reclamation

More Information

https://www.usbr.gov/research/projects/detail.cfm?id=1884

Solution

This research combines laboratory testing with field demonstrations at the Salt River Siphon, the Agua Fria River Siphon, and Fontana Dam to further the EIS method for coating analysis. The placement of testing cells, electrodes used, the accuracy of the various potentiostats used for testing, and testing plans and logistics were evaluated during this study. This work also includes a first approximation for an approach to determining the remaining service life of a coating in the field based on laboratory data for the same coating system.

Application and Results

In addition to finding good agreement between the laboratory and field data, this work made great strides in advancing and refining the field method. In particular, this work resulted in the development of test plans for surveying large structures, as well as developed an approach to test non-horizontal surfaces. As shown in Figure 1, the method was even adapted to be performed upside down. An ASTM international test standard is being developed through work group WK67789 as a result of those advancements, and may facilitate industry wide adoption if approved.

The study also found that measurement accuracy is not affected by the distance between test cells. In addition, this work identified the most accurate hand-held field potentiostat (of the instruments tested), and showed that a single electrode can serve as both the reference and counter electrode in a coupled test setup. Field EIS testing applications include quality control during coating contracts and coating condition assessments for determining and scheduling maintenance.

Future Plans

The field EIS testing method will continue to be refined through the ASTM work group. Additional laboratory testing of commonly used coatings can help to establish the relationship between the EIS results for these coatings and their remaining service life as well as to support the incorporation of this testing method into coating contract specifications. New and emerging hand-held instruments, which can be useful for lower impedance coatings and coatings nearing the end of their service life, should also be evaluated further.