C19 Corrosion Evaluation of Lock and Dam Structure

Charles K. Clarke, PhD, Metallurgical Consulting, 1146 Leroy Stevens Road, Suite A, Mobile, AL 36695; Peter Peterson, PhD, Ivium Technologies USA, 961687 Gateway Boulevard, Suite 201D, Fernandina Beach, FL 32034; and Don Halimunanda, MS, Metallurgical Consulting, 1146 Leroy Steven Road, Suite A, Mobile, AL 36695*

After attending this presentation, attendees will understand the concept of using research type electrochemical techniques for rapid evaluation of corrosion problems involving steel and coatings in lock and dam structures.

The presentation will impact the forensic science community by providing forensic engineers with the ability to rapidly acquire corrosion and/or coating behavior data under the actual conditions of interest.

Literature research revealed the possibility of thermal sprayed coatings providing significant improvements over currently used vinyl coatings for U.S. Corps of Engineers locks and dams. This was confirmed by the following tests:

Electrochemical corrosion methods can be used to rapidly acquire data on the performance of metals and coatings in corrosive environments. Corrosion of metals involves transport of ions and electrons. DC current methods can measure corrosion rate and evaluate pitting and cracking tendencies in metals. Barrier type paint coatings produce a capacitor situation when placed on a steel substrate immersed in water. AC current techniques (electrochemical impedance spectroscopy or EIS) can utilize the effect to monitor moisture transport through coating and ultimately coating break down. Research using these techniques is almost always conducted in controlled laboratory environments. A lock miter gate is exposed to muddy, turbulent, and aerated river water. Tests using both DC and AC electrochemical techniques on actual muddy river water produced some startling results in the area of the current vinyl coatings behavior. Tests were conducted with samples of both vinyl (the current coating) and thermal sprayed coatings immersed in barrels containing aerated, intermittently agitated, muddy river water. (Clear river water was used for some samples.) Previous reported work has utilized small cylinders containing artificial sea water without aeration.

Steel plates coated with 20mil (500 micron) thick layers of thermally applied zinc, aluminum, and zinc -15% aluminum (125 micron surface profile were supplied by two separate contractors and placed into a 55 gallon (210L) drum on a PVC pipe rack. Similar samples of three coat (51 microns) vinyl coat with vinyl zinc rich primer were also provided. One set of the vinyl samples was fully cured. A second set was placed into the water at 24 hour intervals after application to test the effect of not meeting cure requirements.

The AC EIS results on the vinyl coatings were surprising in how fast they exhibited total coating failure. Fully cured samples failed at a slower rate than freshly painted samples but they failed. Failure was indicated in the EIS tests by a drop of several orders of magnitude in measured impedance of the coating. This is evidence for moisture saturation of the coating. The vinyl zinc primer also failed to provide any protection potential. These observations raise serious concern for all of the coated steel structures using these vinyl coating systems.

Thermal spray coatings exhibited no attack or degradation during the tests. Corrosion rates were low thus confirming published work. Both the zinc and zinc-15 aluminum coatings provided good protection potentials to the steel substrate while the aluminum coating was marginal in this regard.

Separate corrosion tests on bare steel in the intermittently stirred, muddy, aerated river water produced very high corrosion rates. Tests on clear river water revealed lower corrosion rates. Prior work suggests that this was the result of iron bacteria.

These results show that thermally sprayed zinc and zinc-15 aluminum are attractive candidates for replacing the current vinyl coatings. Thermal sprayed coatings have no VOC's and are reported to yield at least three times the service life of vinyl coatings. Test results suggest that the vinyl coatings may not provide near the protection expected from them in locks/waters with heavy traffic and water turbulence. Replacing the vinyl coatings with thermal spray coatings has the potential to save enormous amounts of money because shutting a lock down for recoating shuts down the navigable river in many cases. Increasing recoat time by at least three times saves maintenance costs and lost revenue from river traffic.

The electrochemical techniques used for this work can be used in most applications where corrosion is a problem. They have been successfully used in cooling water systems, chemical processes, and other coating studies. They provide the forensic engineers with the ability to rapidly acquire corrosion and/or coating behavior data under the actual conditions of interest.

Corrosion, Corrosion Tests, Infrastructure