CAAP Quarterly Report

Date of Report: 12/30/2024

Project Name: Performance Evaluation and Risk Assessment of Excessive Cathodic Protection on Vintage Pipeline Coatings

Contract Number: 693JK32250008CAAP

Prime University: The University of Akron

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Reporting Period: 10/1/2024-12/30/2024

Project Activities for Reporting Period:

Here are the major project activities for each task:

a) Task 1. Identification of vintage pipeline coatings and influencing factors in coating cathodic disbondment (The University of Akron and Marquette University)

   The Ph.D. Student, Yuhan Su, at The University of Akron has worked on literature reviews to understand pipeline coatings and the influencing factors in coating cathodic disbondment. The conditions where the vintage coating experiences cathodic disbondment and the key influencing factors on the cathodic disbondment have been studied and taken into the experimental design in Task 2.

   Task 1 is completed.

b) Task 2. Evaluation of coating cathodic disbondment considering key influencing factors through laboratory testing (The University of Akron)

   One Ph.D. student, Yuhan Su, and one undergraduate student, Abby Murray, at The University of Akron, are working on this task this quarter.

   Experimental setups and testing procedures have been designed and established for the study of coating cathodic disbondment. Two CP-compatible coatings and one CP-shielding coating have been identified, prepared, and started testing. The influence of CP on coating cathodic disbondment has been studied.

   <u>Coating samples</u>: a liquid epoxy coating, a two-part system designed to protect steel pipe from the harsh effects of corrosion, is used as one representative of a CP-compatible coating. 50 coating panels of this epoxy coating have been prepared in the lab for testing in this reporting period.

   The second representative of a CP-compatible coating—fusion bonded epoxy (FBE) coating has been produced by Midwest Coating Company. The coating samples are customized and designed to have a one-layer FBE coating with a thickness of around 15 mil on a Q-panel substrate. The FBE coating samples are divided into two categories: coating with defects and coating without defects based on their initial electrochemical impedance modulus tested by electrochemical impedance spectroscopy.

The third coating is PE tape, which is selected as one representative of a CP-shielding coating. In this reporting period, 50 panels of this PE coating have been prepared in the lab for testing.

Coating cathodic disbondment testing: The cathodic disbondment of the three types of coatings—liquid epoxy, FBE, and PE tape—is studied by applying different cathodic potentials (-0.775, -1.5, and -2.923 V vs. SCE) under different durations (3, 7, 14, 21 days, 2 months). Each condition will be tested on at least three coating samples.

Coating characterization: The experimental setups for applying CP while monitoring coating disbondment behavior have been designed and used for the testing. The open circuit potential is conducted before and after the cathodic disbondment test. Electrochemical impedance spectroscopy is performed before and after the test. The local pH around the disbondment area is measured by a micro pH meter. The disbonded area of the coating surface is characterized by optical microscopy and analyzed using ImageJ software. Blisters or rusts are visually inspected and recorded followed by a cathodic disbondment test.

c) Task 3. Numerical simulation of pipeline coating disbondment behavior and CP system (Rutgers University)

   The Ph.D. student, Xingsen Yang, at Rutgers University, is working on the COMSOL simulation this quarter. The model setup for coating disbondment modeling has been established. The initial model can provide feedback on current density and pH at different CP levels. The effects of disbondment length, holiday size, disbondment gap, solution resistivity, and oxygen concentration are under investigation.

d) Task 4. Probabilistic degradation model of coated pipe wall due to excessive CP (Marquette University)

   The Ph.D. student, Brigida Zhunio Cardenas, at Marquette University, is working on this task this quarter. The student is collecting coating disbondment data from different CP conditions for the database to generate the degradation model. The coating disbondment data is from 16 experimental studies with 260 data points for 7 coating types. The testing conditions include CP potential, coating thickness, electrolyte pH, and temperature.

e) Task 5. Determination of recoating time using reliability-based approach (Marquette University)

   This task will be started when Task 4 is completed.

Project Financial Activities Incurred during the Reporting Period:

Here is the cost breakdown list for the expenses during the reporting period:

	6/1/2024-12/13/2024
a) Full-time faculty	$11,393.00
b) Graduate assistant	$2,611.75
c) Fringe benefits	$1,996.88
d) Supplies	$8,789.82

e) Travel	$80.39
f) Subaward	$15,120.79
g) Indirect cost	$20,796.17
Total	**$60,788.80**

Project Activities with Cost Share Partners:

No cost-share activity during this reporting period with cost-share partners.

Project Activities with External Partners:

Dr. Qixin Zhou and Dr. Qindan Huang (sub-university) have bi-weekly meetings to update each other on their progress and discuss this project's work. Dr. Huang has her new Ph.D. student to work on this project starting this quarter.

Dr. Qixin Zhou and Dr. Hao Wang (sub-university) have monthly meetings to update each other on their progress and discuss the work of this project.

On December 4, 2024, a mid-term review meeting through Microsoft Teams was conducted with participants of all three PIs and their graduate students, PHMSA personnel, James Powell and Nusnin Akter, to report on this project's progress.

Potential Project Risks:

No potential project risks during this reporting period.

Future Project Work:

The coating cathodic disbondment in Task 2 will be continued for more coating samples to repeat the same condition to generate a reliable statistical analysis. In addition, the underneath metal corrosion will be studied through Tafel testing after a long term of CP. The mechanisms of coating cathodic disbondment under CP will be fully studied.

More liquid epoxy coating panels and PE coating panels will be prepared in Task 2. Another set of commercially prepared FBE-coating will be purchased in the next 90 days.

The COMSOL simulation in Task 3 will conduct sensitivity analysis on multiple parameters to evaluate the influences on the electrochemical process. It also aims to predict the effect of coating disbondment on corrosion rate and metal loss based on experimental measurements.

Task 4 aims to collect more experimental data to develop a prediction model of cathodic disbondment rate including the data generated in Tasks 2 and 3.

Potential Impacts to Pipeline Safety:

Knowing the types of coatings that have issues with excessive cathodic protection brings attention to the pipeline industry to replace these types of coatings in vintage pipelines. Understanding coating disbondment behavior and underneath metal corrosion rate under excessive cathodic protection will provide guidance to pipeline operators.