CAAP Quarterly Report

Date of Report: 6/30/2025

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: 4/1/2025-6/30/2025

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)

   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. There are three subtasks in Task 2:

   Subtask 1 is the evaluation of cathodic disbondment performance in pipeline coatings. The experimental setups, testing procedures, and coating samples are the same as previously reported. The coatings are 1) a liquid epoxy coating, 2) an FBE coating, and 3) a PE tape. The cathodic disbondment 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 is tested on at least three coating samples. Systematic characterizations of coatings are conducted as before. 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.

   Subtask 2 is the onset degradation of pipeline coatings. This is the continuous immersion test for coatings without making an artificial defect on the coating surface. This test is designed to investigate the initiation of cathodic disbondment of different coatings. The same coating samples are used as in subtask 1. The applied CP potential is -2.923 V vs. SCE, and EIS is conducted weekly to monitor the change of the coating to identify the start of the coating cathodic disbondment.

Subtask 3 is the cathodic disbondment assessment of field-aged pipeline coatings. After the mid-term review meeting, we started to study the real vintage pipeline coatings, as we have been provided with some field-aged pipes. The applied CP potential is -1.500 V vs. SCE. EIS, DC current density monitoring, and polarization resistance are tested weekly to track the evolution of coating degradation under the excess CP condition. Because the coating has already failed in the vintage pipe, so far, EIS and other characterization data show no significant change under the excess CP. This subtask is completed.

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 Rutgers team conducted preliminary validation for the previously developed corrosion model with holiday and disbonded coating using experimental data. Laboratory experiments of coating disbondment were conducted using FBE at different CP levels. The disbonded areas were determined after exposure for different days, and the corresponding steady-state DC current values were recorded. On the other hand, numerical simulations were conducted by capturing the experimentally measured disbondment areas as the input. The simulated total DC current was obtained by integrating the distributed current density over the disbonded area. The results show that the simulated total DC current values have good agreement with experimental measurements in general, with a few exceptions that need to be further investigated.

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 Marquette team is studying three degradation models to assess the total degradation (coating disbondment along with steel corrosion). The three individual models are (1) Model 1 for coating disbondment (CD): CD rate vs. applied CP level; (2) Model 2 for steel corrosion: Corrosion rate vs. CP level on steel; (3) Model 3 for CP level on steel under coating disbondment: CP_{steel} vs. $CP_{applied}$. Data collection from the literature review for Model 1 is completed, while the data collection for Models 2 and 3 is still ongoing.

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:

	3/22/2025-6/20/2025
a) Full-time faculty	-
b) Graduate assistant	$3,335.00
c) Fringe benefits	$110.05
d) Supplies	$142.47

e) Travel	$6,250.32
f) Subaward	$3,521.83
g) Indirect cost	$5,115.66
Total	**$18,475.33**

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 the project's work.

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

On June 13, 2025, this project was approved for a one-year no-cost extension. So, the project will end on 9/29/2026.

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. The metal corrosion underneath will be studied through Tafel testing after a long term of CP. The mechanisms of coating cathodic disbondment under CP will be fully studied.

The COMSOL simulation in Task 3 will continue to compare with experimental data to further improve the model accuracy. 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. The three models will be further developed and studied.

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 the underlying metal corrosion rate under excessive cathodic protection will provide guidance to pipeline operators. As the progress of this study, the overprotection issue comes to our attention, and we plan to address this interesting phenomenon through experimental studies.