CAAP Quarterly Report

Date of Report: *January 6, 2016*

Contract Number: DTPH56-15-H-CAP01

Prepared for: *DOT, PHMSA, and Partners*

Project Title: *Corrosion Under Insulation (CUI): Innovative Solutions to Cold Climate Corrosion Challenges*

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For quarterly period ending: *December 31, 2015*

Business and Activity Section

(a) Generated Commitments - No changes in agreements with partners or cofounders. Itemized purchases as follows:

- 1018 Mild Steel Plate (33" x 33" x 3/16") – $41.00
  - Will be used as the test material for corrosion experiments. Additional water jet cutting and sample preparation costs will be incurred next quarter.
- 1-Liter Corrosion Cells (Quantity 6) – £3919.50 ($5,768.96)
  - 1-Liter Cells will provide the baseline corrosion rates in various solutions. Each experiment requires a 30 day exposure time, so multiple cells will result in a timely completion of the research.

(b) Status Update of Past Quarter Activities - All tasks reported below funded by PHMSA.

- Acquisition of metal samples for corrosion testing.
  - Five metal supply companies were contacted trying to find the best material to be used in the experiment. Initially, it was proposed that metal conforming to specification API 5L X65 should be used. Several quotes were obtained on various metals with costs ranging from $16 to over $3,000. After some discussion with collaborators at BP Alaska, 1018 mild steel was determined to be a representative and cost-effective sample material. The steel plate was purchased locally (as itemized above).
- Metal coupon sample fabrication.
  - A local shop was contacted and will water jet cut samples from the steel plate to specified sizes. The equipment is currently under repair and should be operational in the 2nd week of January. Additional surface preparation of the metal coupons will be done in the lab after samples have been cut.
- Sodium bentonite acquisition.
  - Several companies were contacted to obtain "pure" sodium bentonite. A local drilling company has some extra bentonite that is available for no cost. It will be picked up and brought to the lab sometime during the 1st week of January. A second sodium bentonite supplier based in Illinois can provide very fine powdered bentonite at a low cost of $10 per 50 lbs. The supplier is having difficulty with shipping and the quote is still in process.

- Insulating foam research and acquisition.
  - The original construction insulation foam on the Trans-Alaska Pipeline System contains chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) which may produce increased fluoride and chloride content in the corroding solutions found under insulation. In 1987, the Montreal Protocol was established to reduce and phase out substances that deplete the Earth's ozone layer. Among those substances are almost all CFC's and HCFC's. As a result, obtaining insulating foam similar to the original construction material can only be done by harvesting foam from existing pipe sections. The Asset and Integrity Corrosion (AIC) lab has some legacy foam on hand. Additional foam will be of the non-CFC/HCFC formulation.
  - The plan moving forward will be to use the original construction foam to create foam slurry corrosion solutions.
  - A new construction foam has been sought out from local insulation companies. It will be purchased and formed for an experimental apparatus to create a crevice between the steel sample and the insulating foam.
- 1-Liter Cell acquisition.
  - 1-Liter Cells were purchased for baseline corrosion rate determination. These cells will be used to conduct 30 day corrosion exposure experiments. The primary method will be measuring weight loss of the metal samples. A secondary method will be a Linear Polarization Resistance (LPR) measurement. The corrosion rates determined by LPR will be compared to those determined through weight loss.
- Apparatus design and construction.
  - The original Foam Crevice Cell apparatus design has been modified slightly. A glass cylinder with two ports for inlet and exit fluid will be the base. Inside the glass, there will be a metal coupon, in the form of a disc, which is held in place by a plastic frame which will allow the experimental solution to immerse both sides of the metal. On both sides, insulating foam will sandwich the metal to create a crevice similar to actual conditions of corrosion under insulation. See Figures 1, 2, and 3.

Figure 1: Modified Foam Crevice Cell.

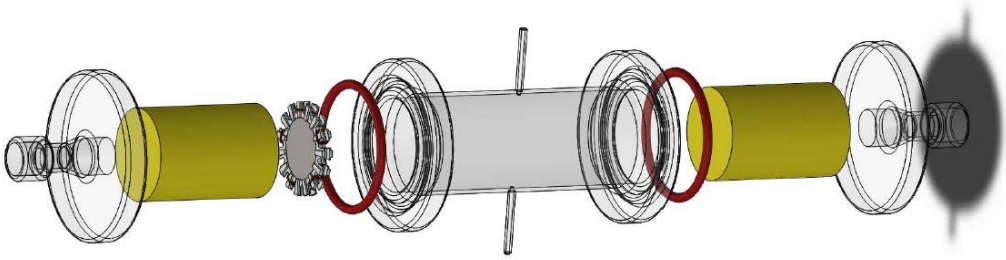

Figure 2: Foam Crevice Cell exploded view.

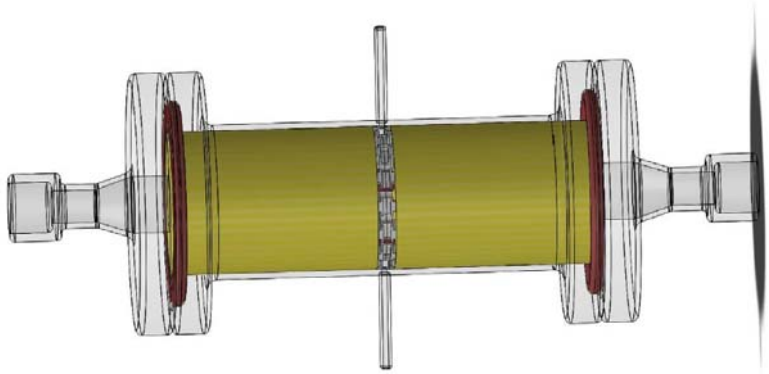

Figure 3: Foam Crevice Cell collapsed view.

- The size of the coupon disc will either be 1” diameter or 1-1/4” diameter. Two separate plastic coupon holders have been created via SolidWorks software and will be 3D printed in the 1st week of January. The size of the coupon will be finalized after evaluating the fit and exposure of the metal to solution.
- Heat tape is the current proposed method of maintaining the correct solution temperature throughout the experiment. Reading and research has been conducted on the particular size and brand of heat tape to be used. Additionally, an existing temperature controller in the AIC lab will be used to control the heat tape on/off switching.

- Rainwater synthesis.
  - Research and reading has been conducted on how to best acquire or synthesize rainwater. The 1985 “Development of a Standard Reference Material for Rainwater Analysis” will be the starting point for creating a standardized rainwater used in the experiments.

(c) Description of any Problems/Challenges -

- Acquisition of metal samples.
  - Original quotes for metal conforming the specification API 5L X65 were prohibitively expensive and intensified the search for a cost-effective material that is representative of the actual pipe material. The expense was quite a shock, but the problem has been resolved. No further action is necessary.
- Sodium bentonite acquisition.
  - Acquiring a fine powder substance of sodium bentonite required contacting multiple companies. Most sell large 1/8” diameter chips for use in manmade ponds, but the powder is the proposed method for inserting bentonite into the annular space between the insulation and the pipeline.
- Apparatus design and construction.
  - This may prove to be slightly difficult in the future. Current issues include determining the best size for the metal coupon and the best way to create a foam/metal crevice. This challenge will be resolved with further construction efforts.
- Insulating foam composition.
  - Due to the 1987 Montreal Protocol, the insulating foam used in the experiment will not be the exact type as used in original construction. However, the corrosion exposure foam slurry solution can be generated using the original construction foam. Additional modifications to the exposure solution can be made by adding chemical compounds to achieve the desired pH and solution contents. This challenge will be resolved with further testing.

(d) Planned Activities for the Next Quarter -

- Metal sample preparation.
  - Metal samples will be water jet cut and surfaces will be finished per applicable ASTM standards and references.
- Apparatus design and construction.
  - The initial iteration of the foam crevice cell device will be tested in a 30 day exposure experiment. Modifications will be designed and implemented as necessary afterwards.
- Rainwater synthesis.
  - Actual synthesizing of rainwater will be completed.
- Corrosion solution preparation.
  - The solutions that will be exposed to the metal samples will be created and tested for pH and molecular content. Additional modifications will be made to approximate actual field conditions.
- 1-Liter Cell testing.
  - Baseline experiments will be conducted for 30 days of exposure using 1-Liter cells and the finalized corrosion solutions.