FIU PROJECT 1

CHEMICAL PROCESS ALTERNATIVES FOR RADIOACTIVE WASTE

FLORIDA INTERNATIONAL UNIVERSITY

FIU Personnel and Collaborators

FIU Applied Research Center

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Project Tasks and Scope

FIU Applied Research Center

Task 17: Advanced Topics for Mixing Processes

- Investigate formation of sediment beds and pipeline flushing operations via FIU test loop

Task 18: Technology Development and Instrumentation Evaluation

- Development of inspection tools for waste transfer lines and DST primary tanks
- Investigate approaches/coatings to protect the walls in the exhaust channel at H-Canyon

Task 19: Pipeline Integrity and Analysis

- Pipeline corrosion and erosion detection
- Nonmetallic materials evaluation

Task 17 - Advanced Topics for Mixing Processes

17.2 - Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

Site Needs:

- According to the Defense Nuclear Facilities Safety Board, a number of issues still exist regarding the slurry transport and flushing strategies at Hanford.
- A series of flushing tests can address a variety of technical gaps associated with flushing techniques and would be beneficial to both Hanford and Savannah River.

Objectives:

- Conduct a series of experimental tests to bridge technical gaps associated with the flushing of HLW within the transfer systems at Hanford and Savannah River.
- Tests will continue to be conducted using the flushing loop that were developed in the previous year.
- The loop can be expanded to multiple of its lengths ranging from 165 ft to 825 ft for scale up analysis (study of length effect on flush operation efficiency).

Supernatant Dried on Nozzle 18 in AP Valve Pit.

Task 17 - Advanced Topics for Mixing Processes

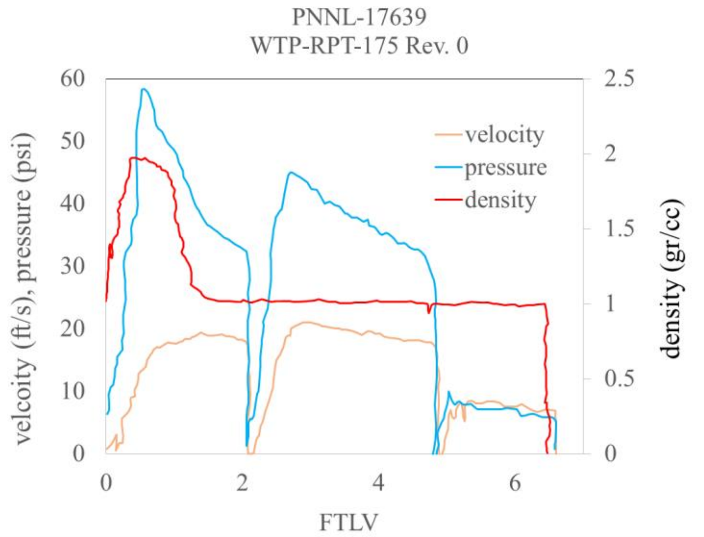
17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

Applied Research Center

Background:

- Current guidelines for flushing at sites:
  - TFC-ENG-STD-26, REV C-1 and STD-26 or RPP-RPT-59600 Rev.00
    - Minimum flush to line volume (FTLV): 1.5; Recommended FTLV: 1.5-3
    - Minimum flush velocity (FV): 10 ft/sec; Recommended FV: 4 to 6ft/s
    - Maximum FV: 10 ft/s (if glass formers present) and 12 ft/s (if no glass formers)

- Previous flushing tests results (PNNL-17973.WTP-RPT-178 Rev. 0 and PNNL-17639. WTP-RPT-175 Rev. 0)
  - FV higher than erosion-safe limit
  - Pre-pressurized water rather than pump
  - No data for post flush evaluations
  - FTLV values exceeding 6 were reported

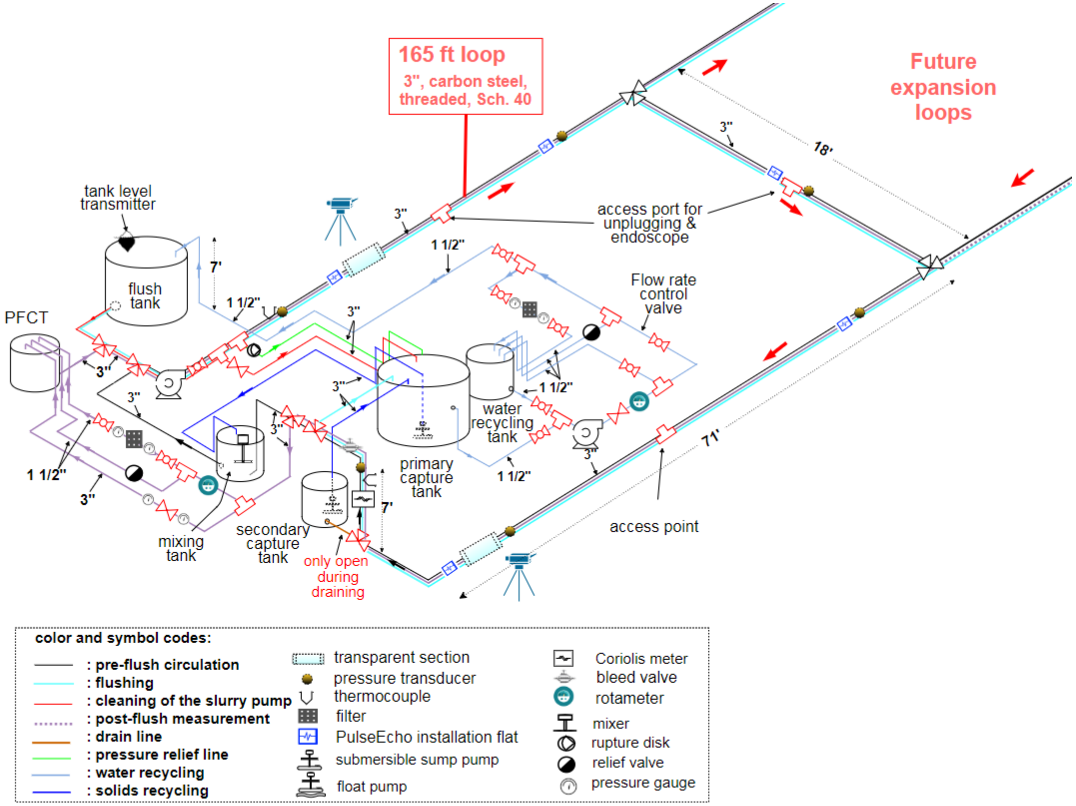


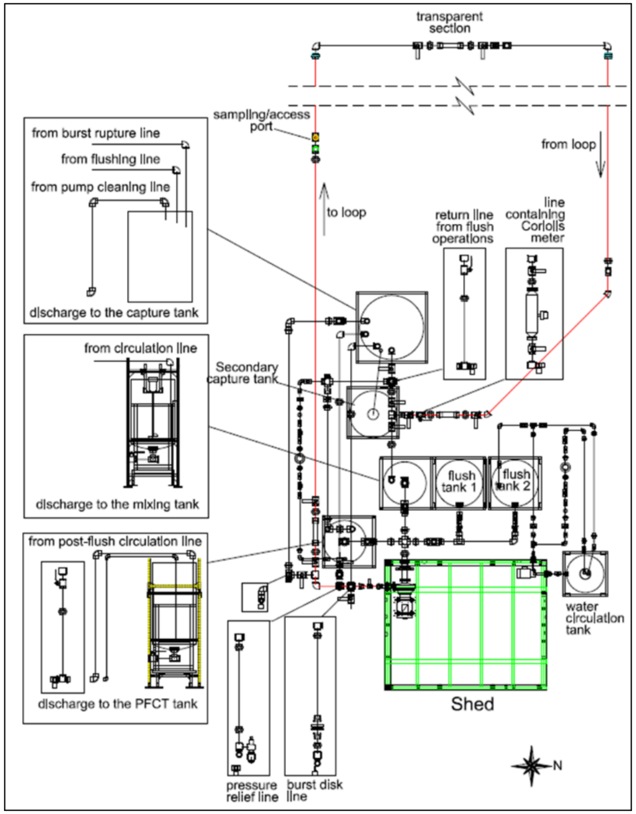
Task 17 - Advanced Topics for Mixing Processes

17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

Schematic of Flushing Loop

- Multiples of 165 ft (up to 825 ft) , 3 in Sch. 40 carbon steel
- Circulation, flushing, filtration, water and sediment retrieval, post-flush evaluations





Task 17 - Advanced Topics for Mixing Processes

17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

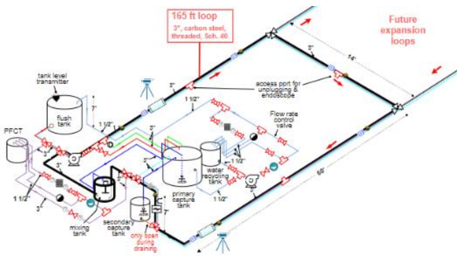
FIU Applied Research Center

Preliminary Testing

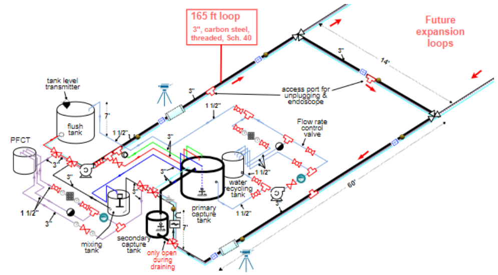
- Leak test all system parts, pump control automation using VFD software

Task 17 - Advanced Topics for Mixing Processes

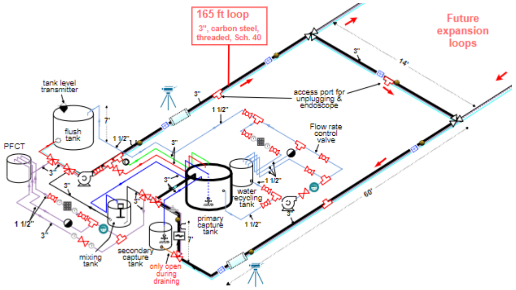
17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River



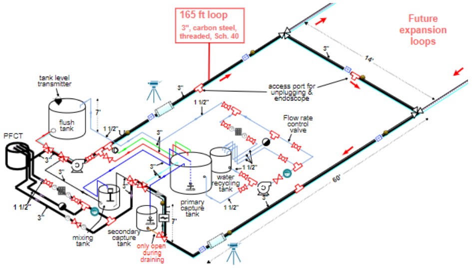
circulation mode



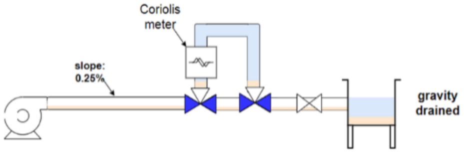
Drain mode



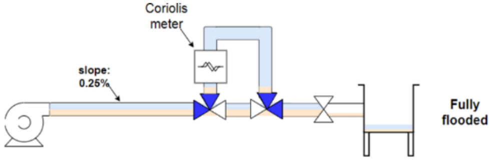
flushing mode



Post-flush circulating mode



Drained I.C.



Fully-flooded I.C.

Task 17 - Advanced Topics for Mixing Processes

17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

Test Number	Flush Mode	Kaolin Percent	Mode	Resultant flush time (sec)	Resultant FTLVR
1	Constant	10	Fully-flooded	28.5	1.22
2	Pulsed	10	Fully-flooded	-	-
3	Constant	15	Fully-flooded	-	-
4	Pulsed	15	Fully-flooded	-	-
5	Constant	20	Fully-flooded	35.4	1.40
6	Pulsed	20	Fully-flooded	-	-
7	Constant	10	Gravity Drain	23.2	1.17
8	Pulsed	10	Gravity Drain	-	-
9	Constant	15	Gravity Drain	27.1	1.31
10	Pulsed	15	Gravity Drain	-	-
11	Constant	20	Gravity Drain	26.5	1.36
12	Pulsed	20	Gravity Drain	-	-

Constant mode @ 17 ft/s. **Pulse** mode: 17 ft/s ~ 0 ft/s

Resultant results is the time or FTLV needed to achieve a density below water (1000 kg/m^3)

Task 17 - Advanced Topics for Mixing Processes

17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

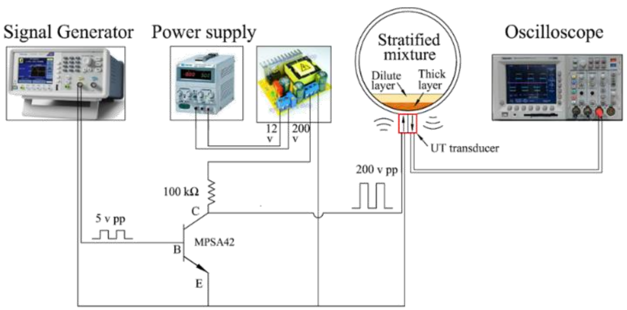
Mixing kaolin slurry

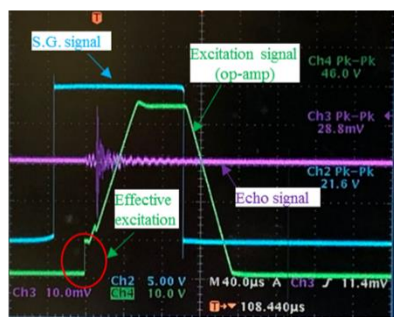
Initial - 1 day of settling

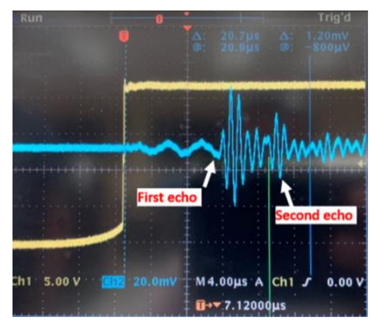
Midway through flushing trial

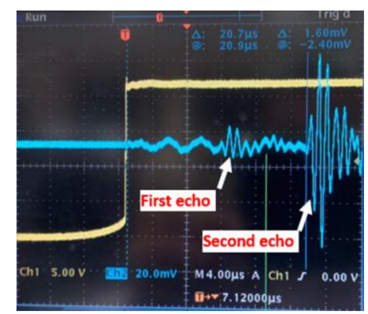
After flushing

10% Kaolin Flushing Trial







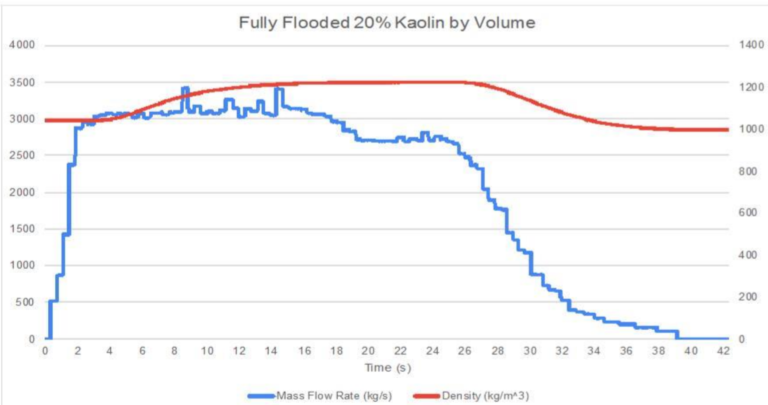


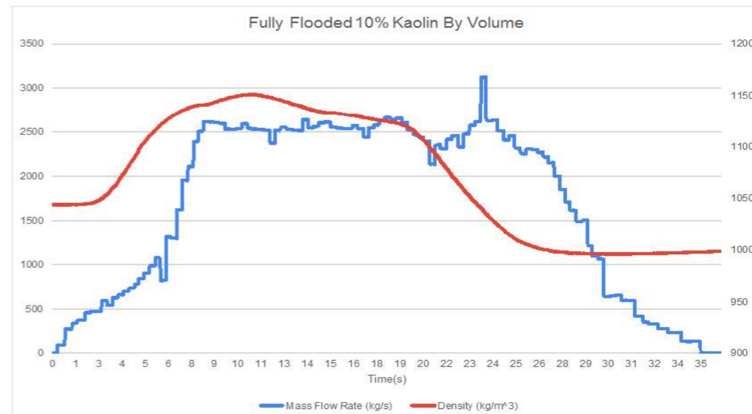
Task 17 - Advanced Topics for Mixing Processes

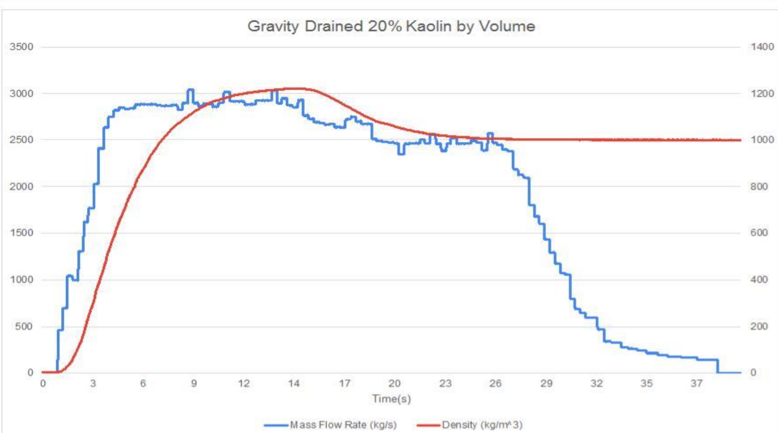
17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

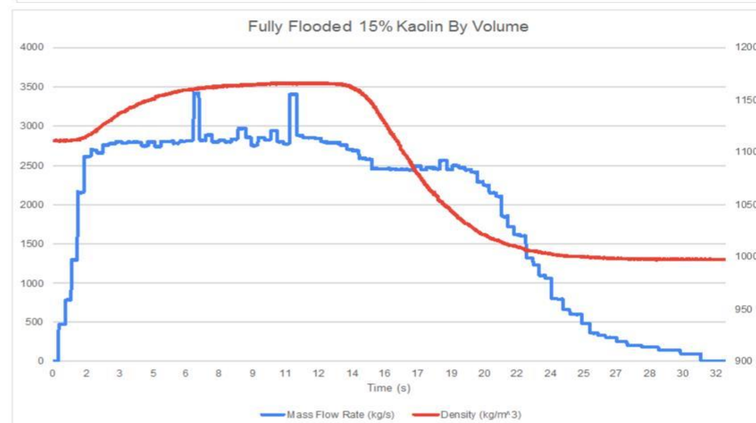
FIU Applied Research Center

Experimental Results









Task 17 - Advanced Topics for Mixing Processes

17.2 Evaluation of pipeline flushing requirements for HLW at Hanford and Savannah River

Proposed Scope for Performance Year 01*

- Expand test loop to 330 ft
  - Validate the functionality of the system and instrumentation
- Continue to investigate the ability to characterize the initial conditions (fully-flooded and gravity-drained)
- Develop computational tools to create a virtual environment for evaluating different simulants and pipe geometries.
- Investigate the use of different simulant – i.e. higher density particles, complex mixtures.

Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

FIU Applied Research Center

Site Needs:

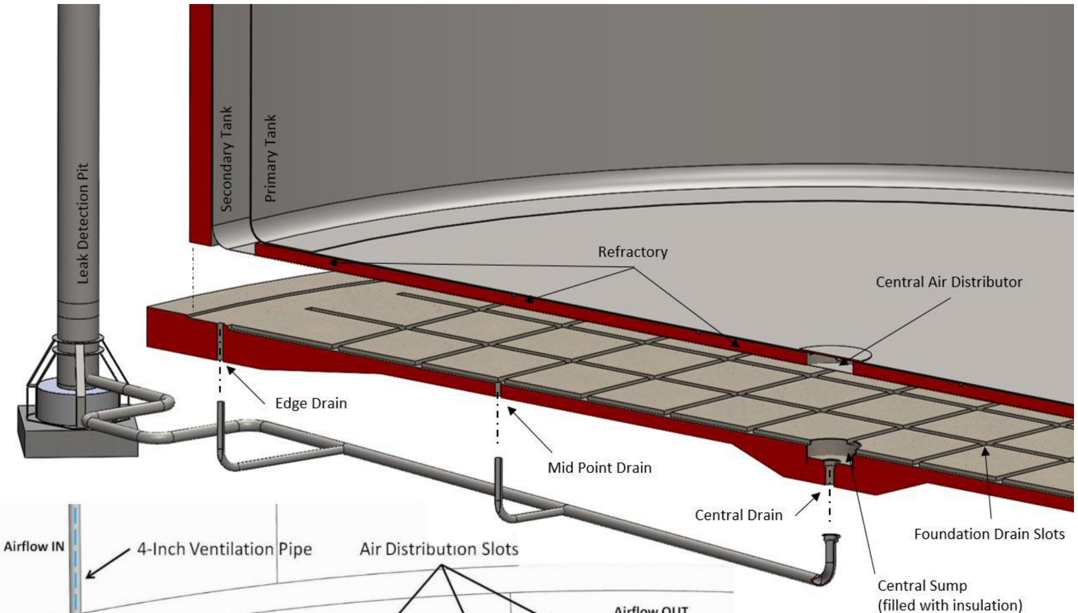
In 2012, tank waste was found in the annulus of AY-102. In addition, thinning (up to 70%) of the secondary liner in the annulus region has also been observed in other double shell tanks (DSTs). Understanding of the structural integrity of all DSTs at Hanford is of paramount importance - thus, the significant need for development of tools/sensors that can provide information regarding the health of the tanks.

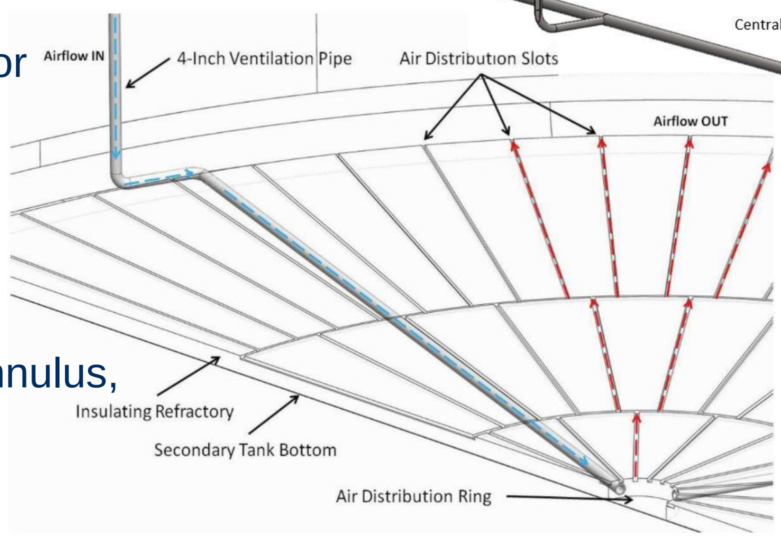
There are three possible entry points:

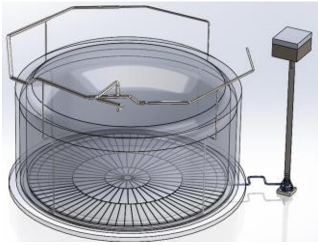
(1) refractory air slots through the annulus,

(2) 6” leak detection piping,

(3) 4” air supply piping







Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

Mini Rover

Objective:

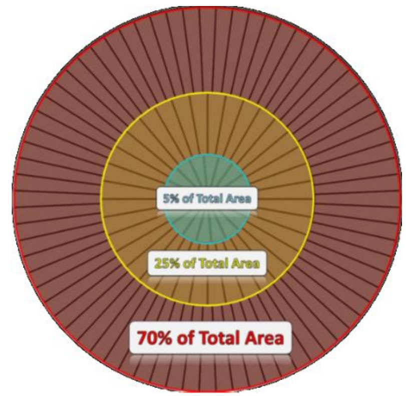
Develop cost effective inspection tools that can travel through the refractory pad air channels underneath the primary liner and the drain line channels underneath the secondary liner while providing live video feedback.

Current Task:

Continue to develop our miniature rover to provide information regarding the health of the primary liners. This includes optimization of the design, development of a cable management system, sensor integration and demonstration on a full-scale mockup.

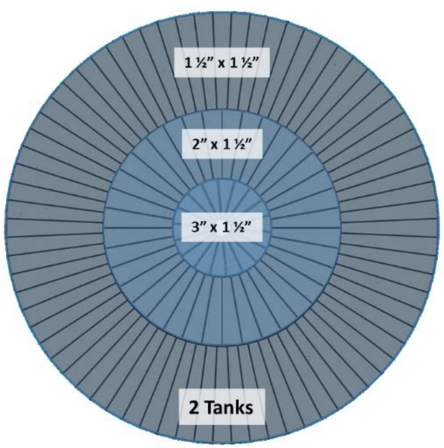
Design parameters:

Travel through small cooling channels, remote controlled, provide live video feedback, rad hardened (~ 80 rad/hr), withstand relatively high temperatures (~ 170 °F), navigate ~ 50 feet to the tank center, maneuver through four turns, subject channel to pressures not greater than 200 psi.



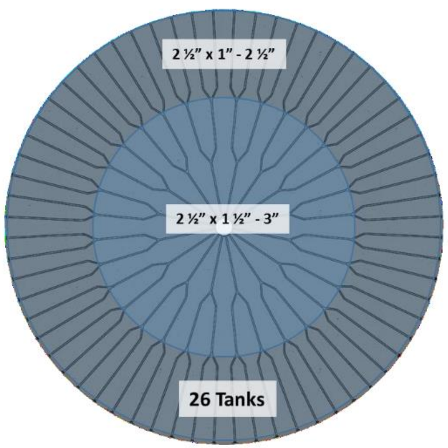
(Kayle Boomer, WRPS 2015)

AY
Tank Farm



(Brandon J. Vazquez, WRPS 2015)

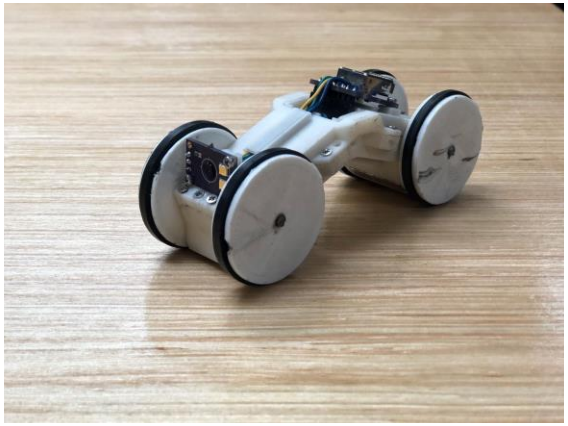
AZ/SY/AW/AN/AP
Tank Farm



(Jason Gunter, WRPS 2015)

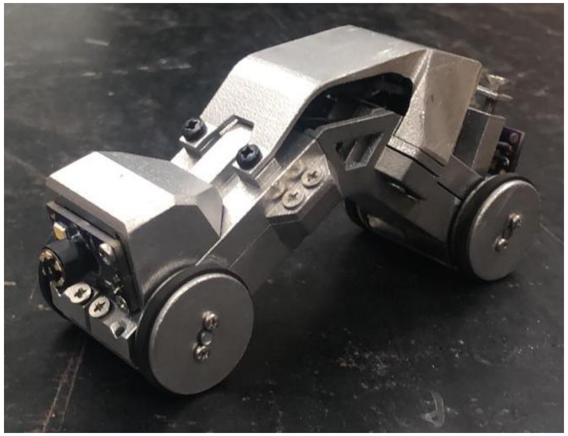
Task 18 - Technology Development and Instrumentation Evaluation

Improved Design



Prototype

- V-Shape rover design provides clearance in the middle of the unit.
- Capable of traversing weld seams in forward and reverse directions up to 1”.
- The developed prototype was not robust for operations in the channel.
- Motors under powered to provide sufficient power for turning capabilities.

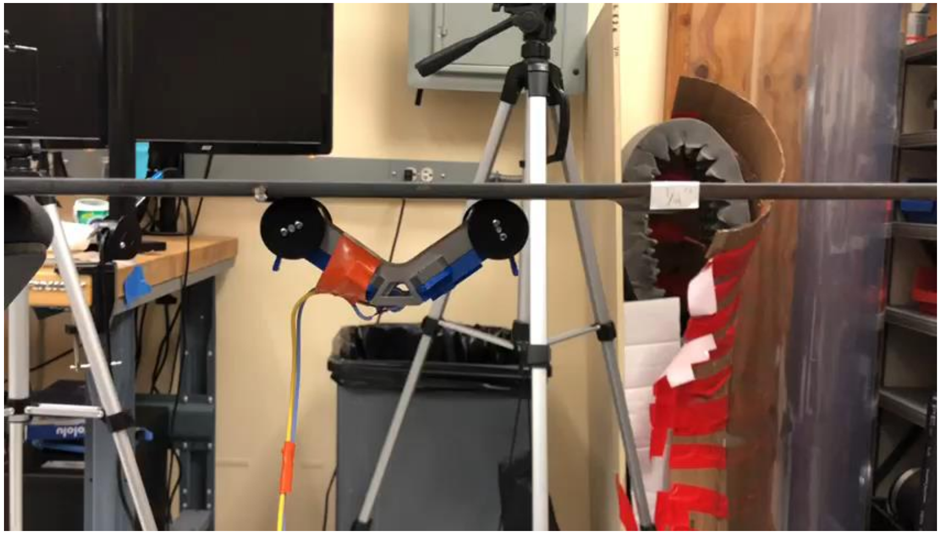


Final Design

- With this concept in place, a bevel gear design was incorporated to transfer power.
- Smaller diameter wheels were incorporated to allow for ideal maneuverability.
- This position change, made it possible to utilize micromotors with higher stall torques (140 oz.in).
- Rovers body printed in aluminum to enhance durability and strengthen the robot.

Task 18 - Technology Development and Instrumentation Evaluation

Mini Rover Testing



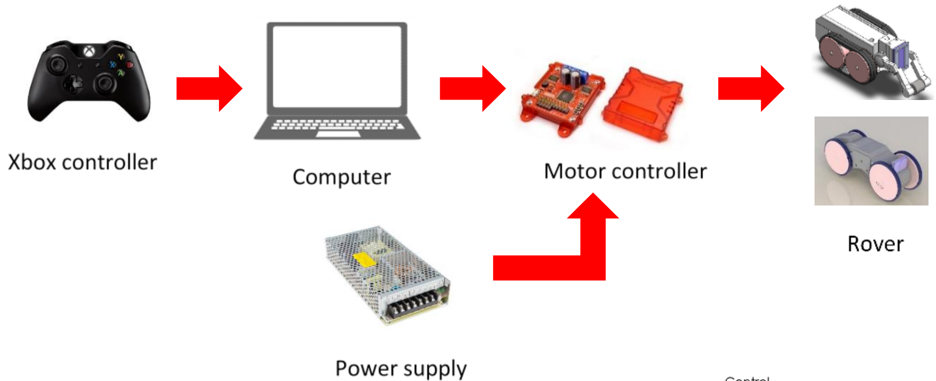
Mini Rover traversing weld seams up to 1”

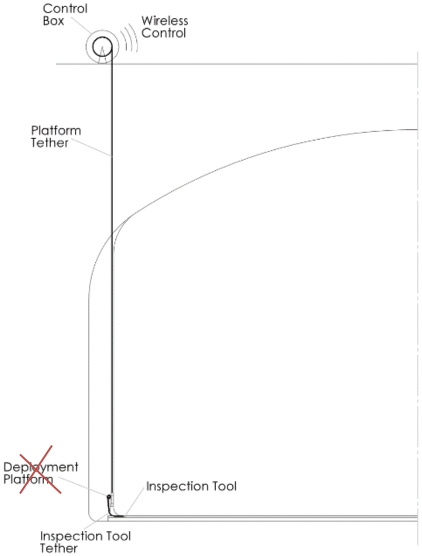
Mini Rover traveling through the mockup

FIU Applied Research Center

Task 18 - Technology Development and Instrumentation Evaluation

Mini Rover Control Box



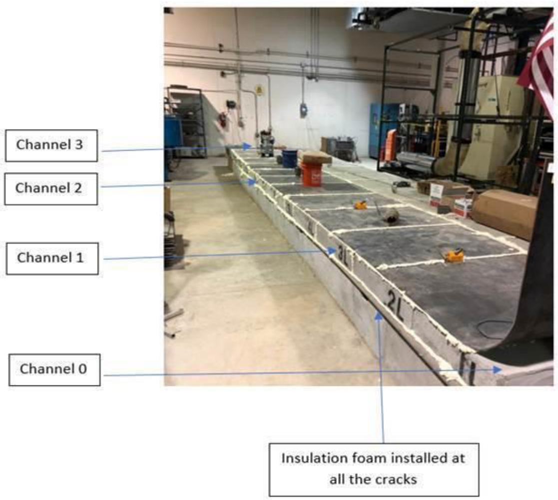


- The control box was developed to deliver power and receive quality video beyond 150’.
- With the generic design of the box, it is suitable for all our robotic platforms.
- Control box passed its OSHA approved field evaluation electrical safety inspection.

Task 18 - Technology Development and Instrumentation Evaluation

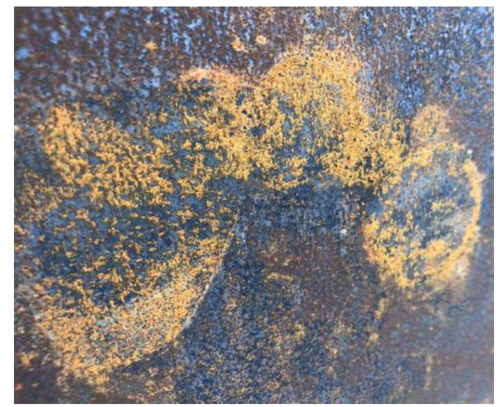
Deployment Testing

Durability Test
(20 Trials)



Weld Seams Test
(10 Trials)

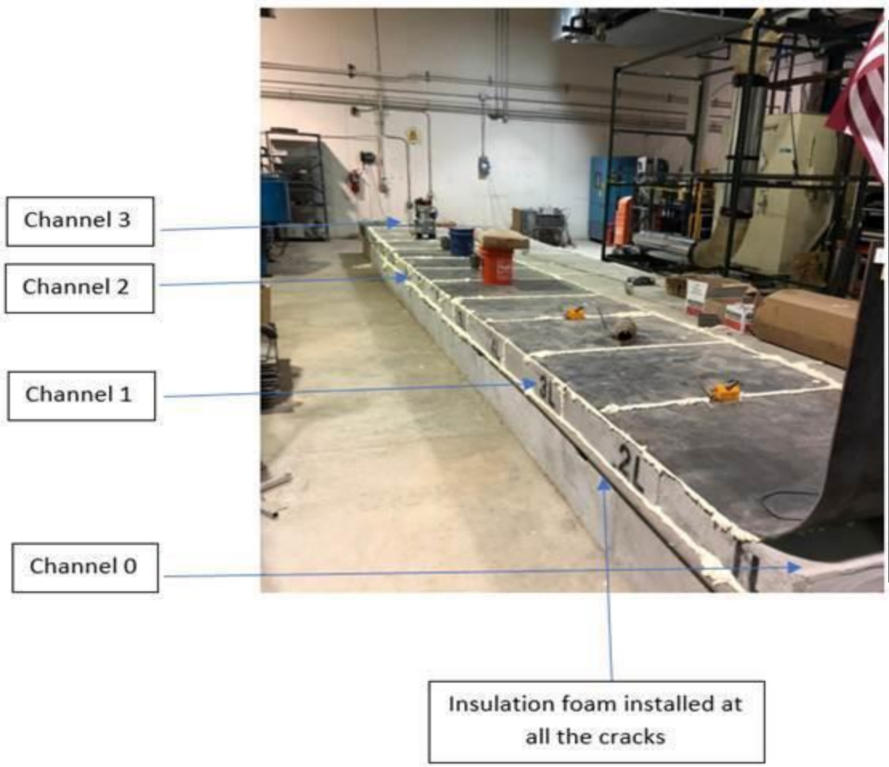
Corrosion Test
(2 Trials)

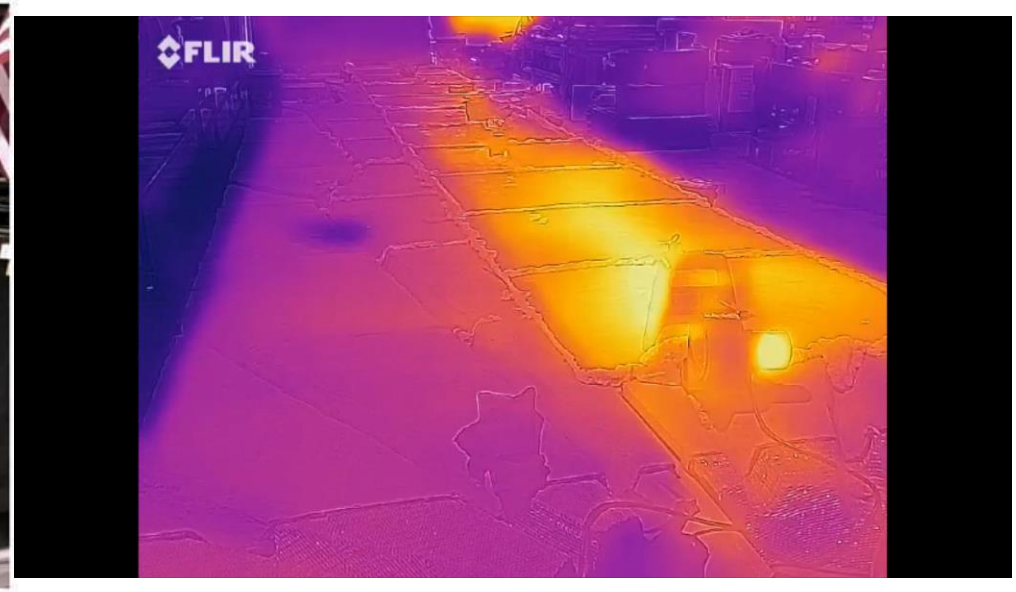


The durability test is put in place to test the mini rover of its capabilities under harsh environments. The mockup above is at an elevated temperature (~130-degree F).	For the weld seam test, we will introduce weld seams into to mockup and monitor the rover's capabilities of traversing over the weld seams (10 trials).	Corrosion test consists of running the rover over a corroded surface and document the rover's capabilities with the material buildup adhered to the magnets.

Task 18 - Technology Development and Instrumentation Evaluation

Deployment Testing

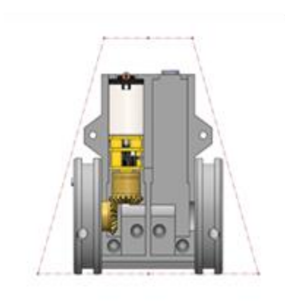


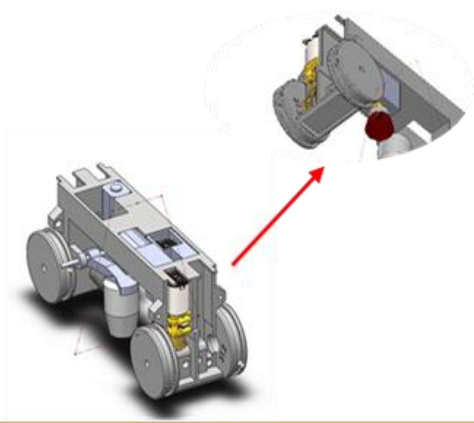


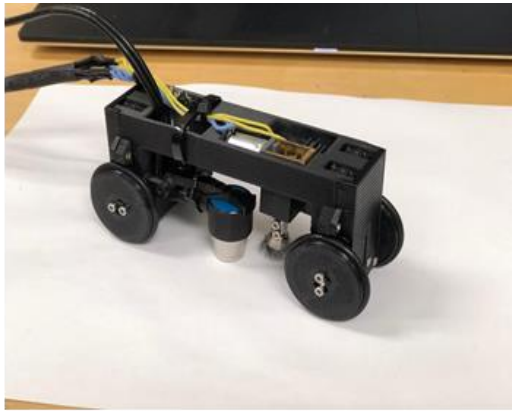
Task 18 - Technology Development and Instrumentation Evaluation

Mini Rover with UT Sensor Integrated

- Design based on V-shape rover to be able to conquer weld seams, capable of traversing over weld seams of 3/8”.
- This position change, made it possible to utilize micromotors with higher stall torques (46 to 140 oz.in) along with the bevel gear design.
- Onboard cleaning mechanism in place to prep the surface for UT measurement.
- The UT sensor is positioned just before the cleaning mechanism and is capable of retracting and extending to provide clearance for normal traveling operations along with the coupling application tube.

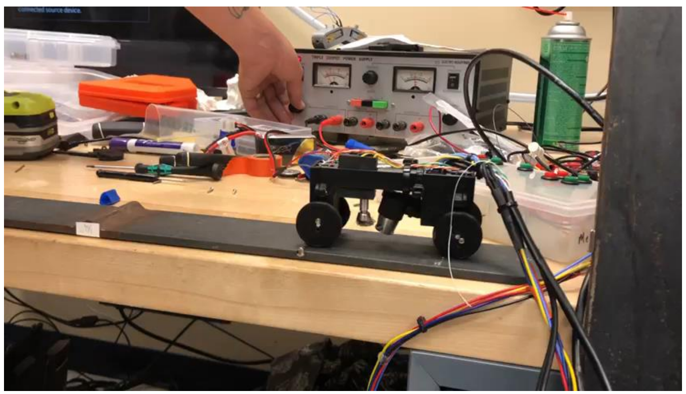






Task 18 - Technology Development and Instrumentation Evaluation

Mini Rover with UT Sensor Integrated



UT Rover traversing over weld seams up to 3/8”

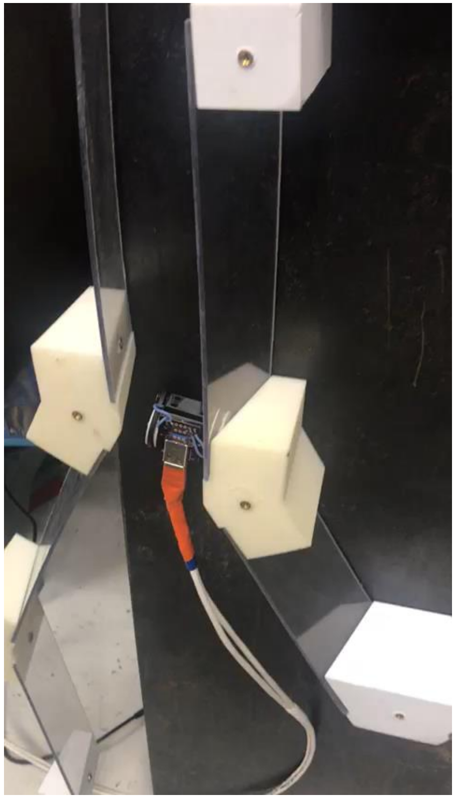
Surface preparation

UT Rover obtaining thickness measurement

Task 18 - Technology Development and Instrumentation Evaluation

90° Mini Rover for AY-101

Four 90° turns



- This unit is designed to accomplish four 90-degree turns.
- Is equipped with 2 camera printed circuit boards (PCB) to relay live feed video back to the operator.
- Pull force is rated at 3.87 lbs. providing great maneuverability.

Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

Secondary Liner Inspection

<ins>Objectives</ins>:

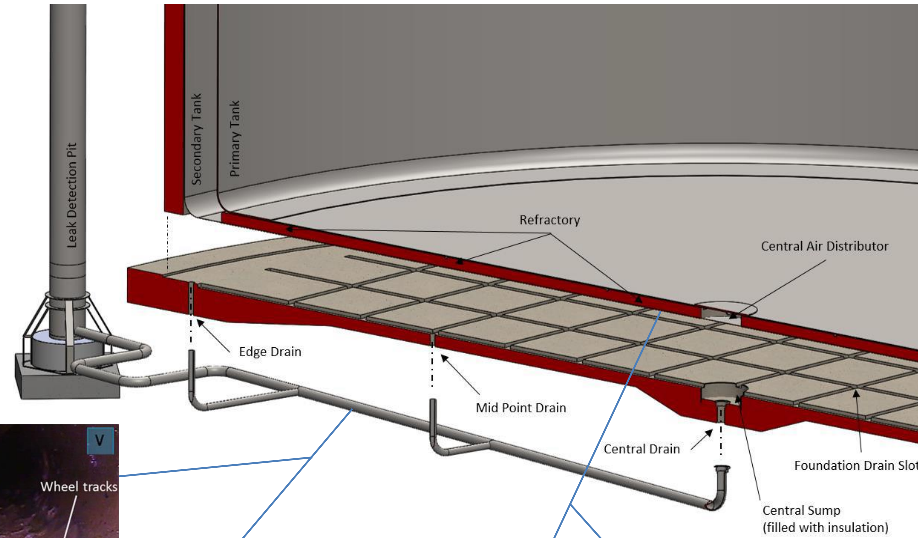
Develop an inspection tool that navigates through the foundation drain slots under the secondary liners of the DST's at Hanford while providing live video feedback.

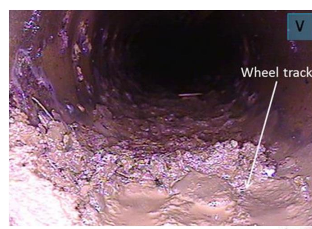
<ins>Current Efforts</ins>:

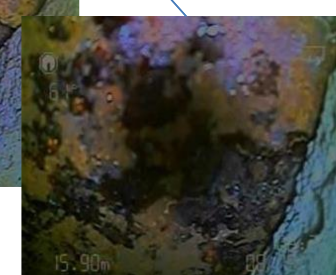
Develop a marsupial type crawler that can traverse through the drain Lines and deploy a rover into the drain slots.

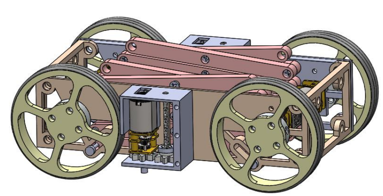
<ins>Expected Conditions:</ins>

- No radiation
- Irregular weld seams
- Mud, scaling, build-up, and corrosion



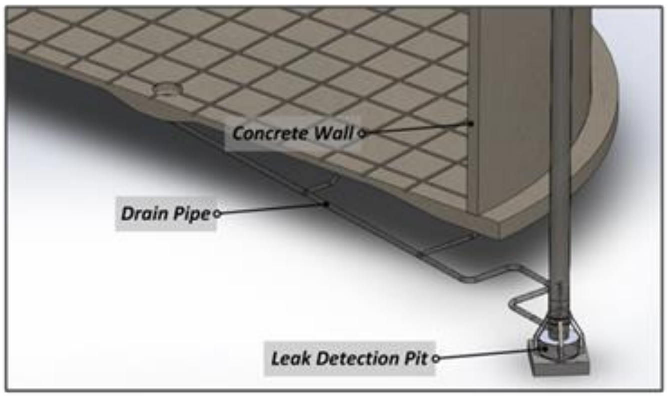




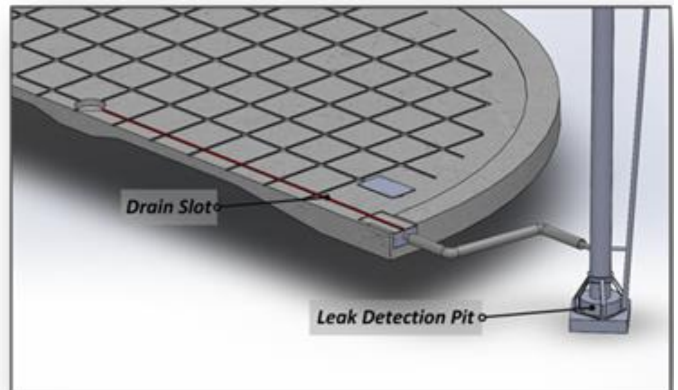


Task 18 - Technology Development and Instrumentation Evaluation

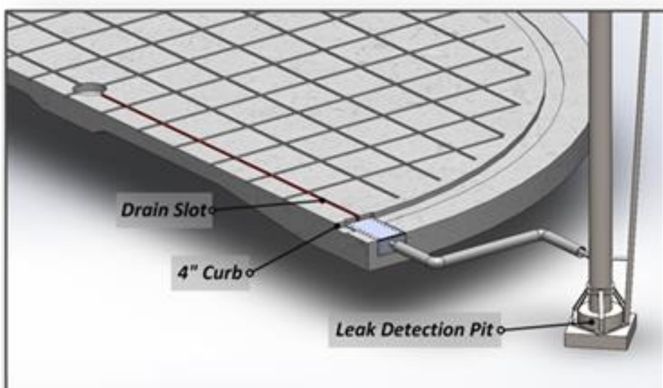
18.2 - Development of Inspection Tools for DST Primary Tanks



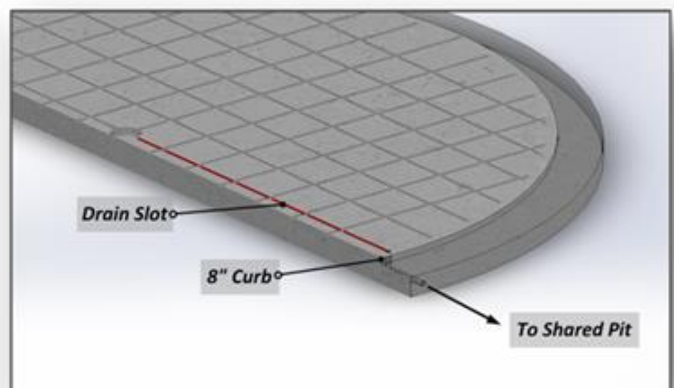
241-AY, AZ, and SY Design



241-AW and 241-AN-107 Design



241-AN Design



241-AP Design

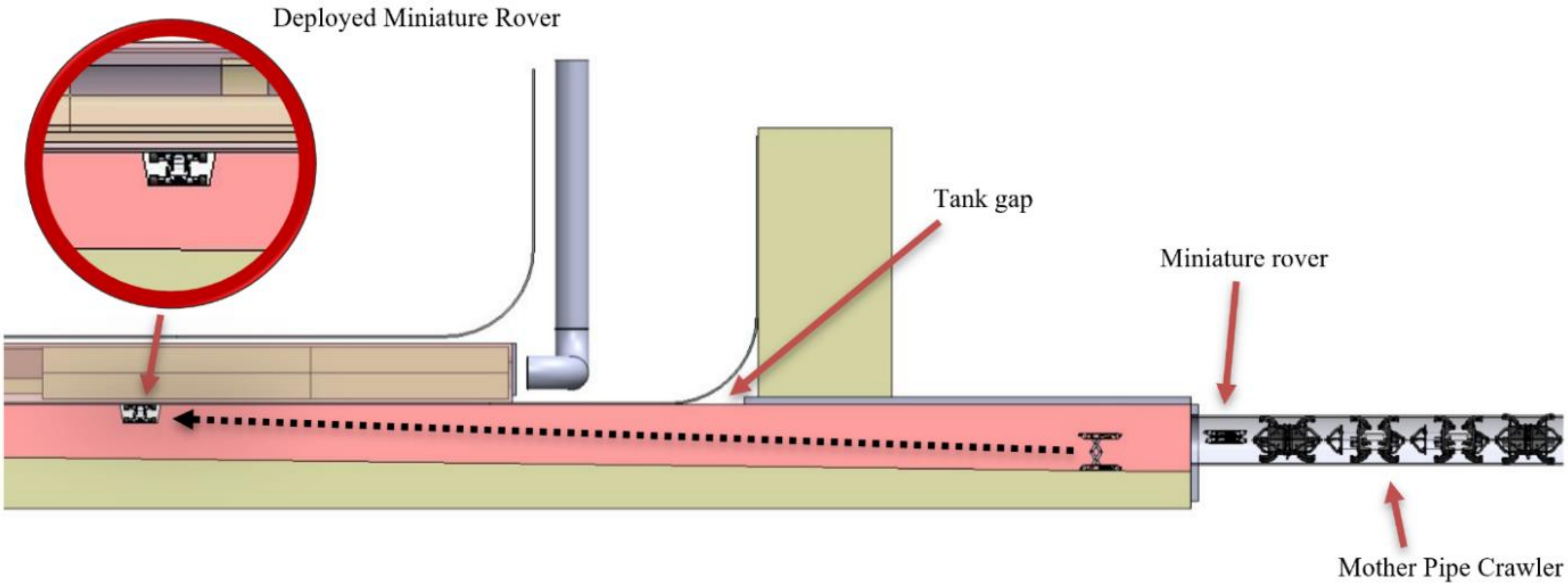
Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

<u>Proposed inspection</u>

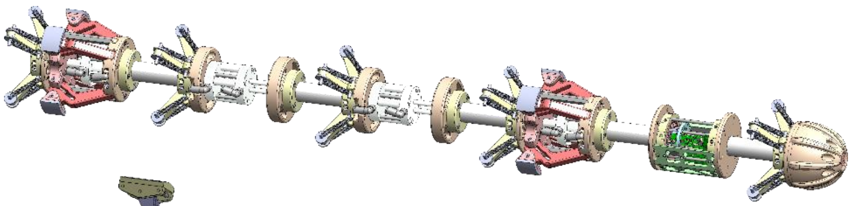
A mother pipe crawler, similar to others developed at FIU, will:

- house and deploy an inspection rover, and
- handle retrieval and cable management



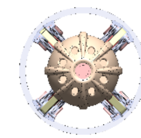
Task 18 - Technology Development and Instrumentation Evaluation

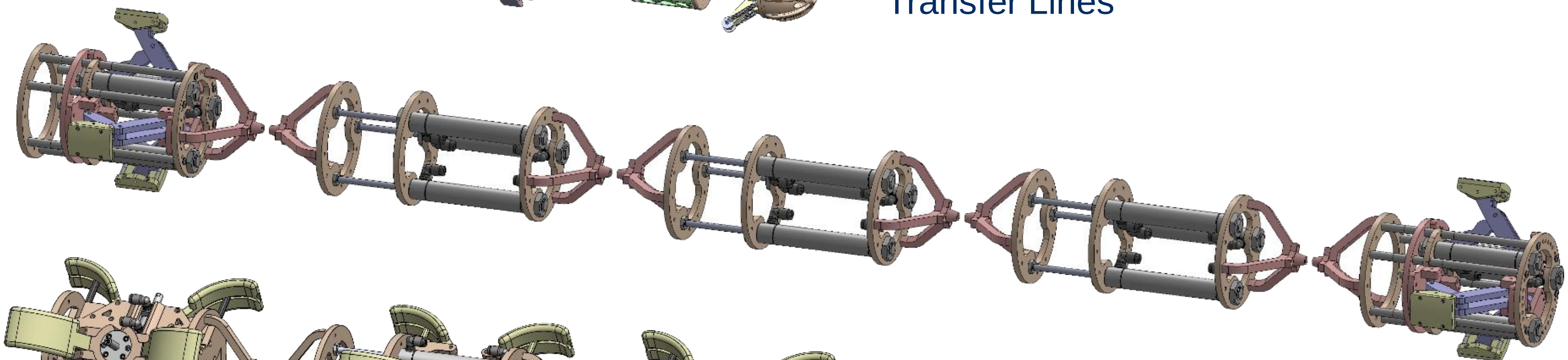
18.2 - Development of Inspection Tools for DST Primary Tanks

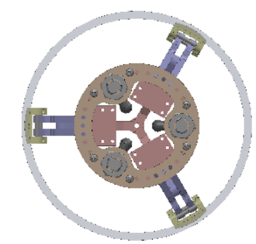


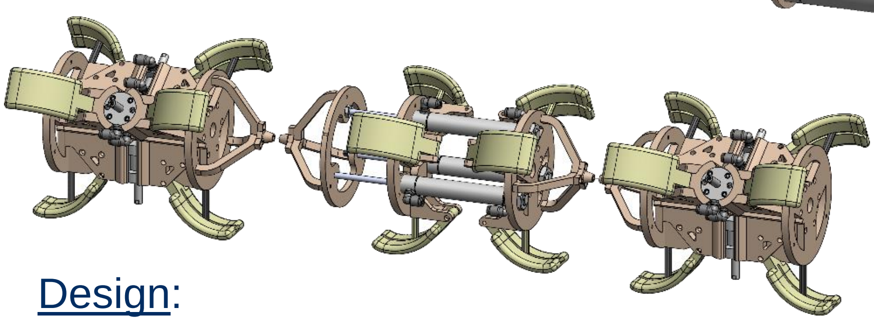
DST's Ventilation Header, and Transfer Lines

3”Ø & 4”Ø



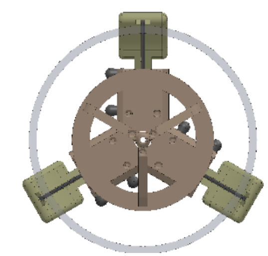






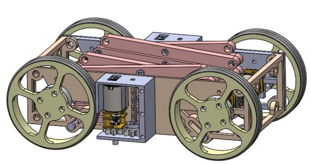
DST's Drain Line

6”Ø



Design:

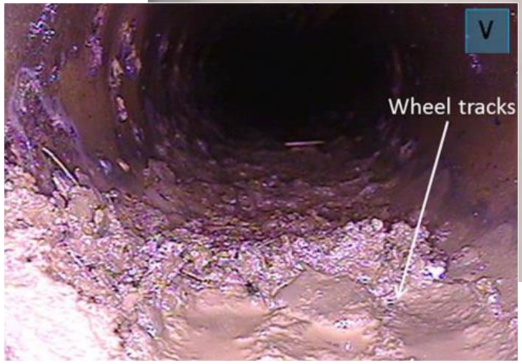
- Modular design
- Peristaltic locomotion
- Pneumatic actuation
- 3D printed parts

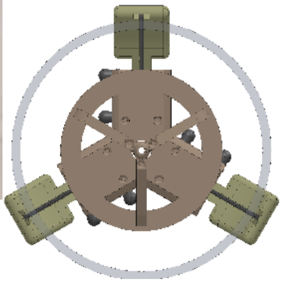


DST's Drain Slots

Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

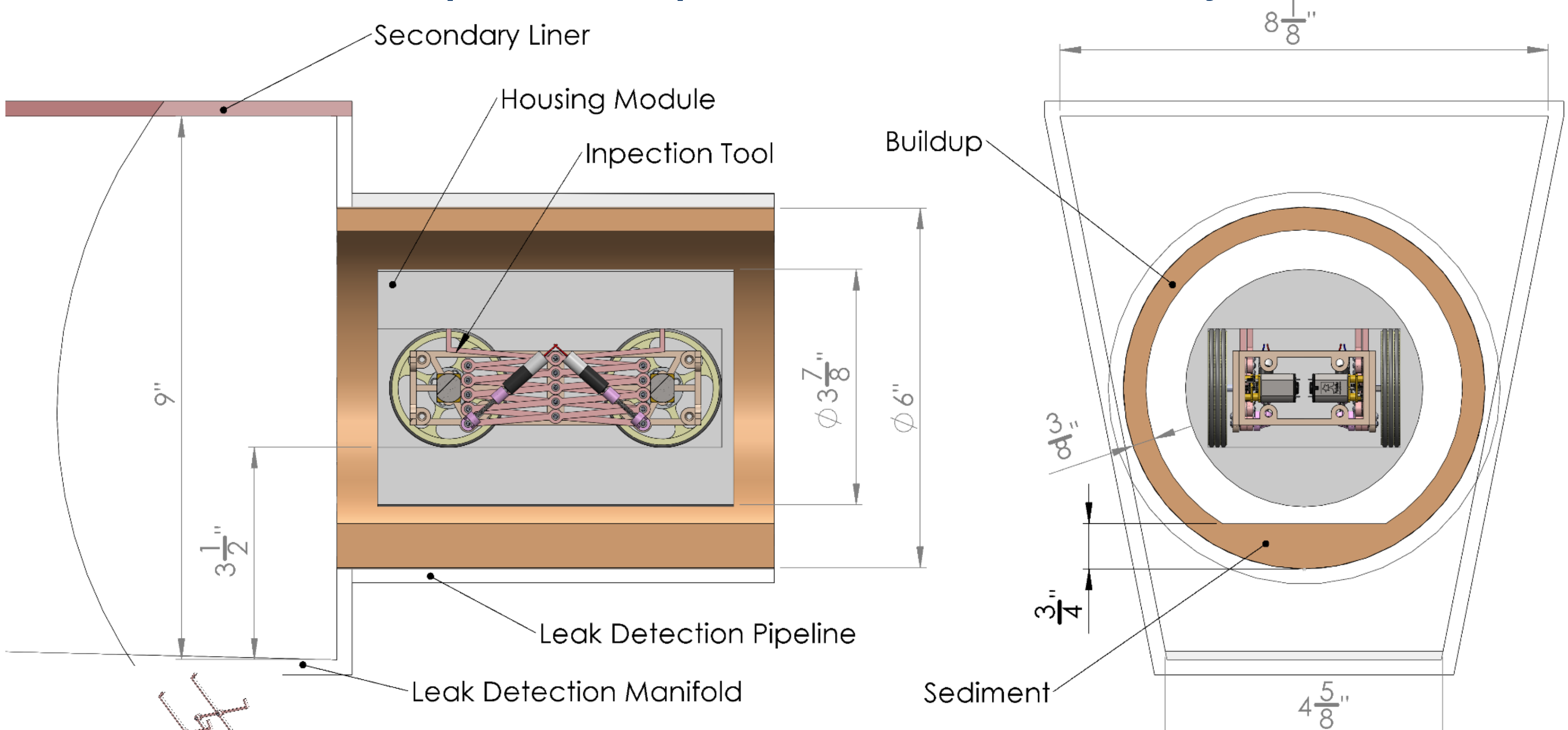


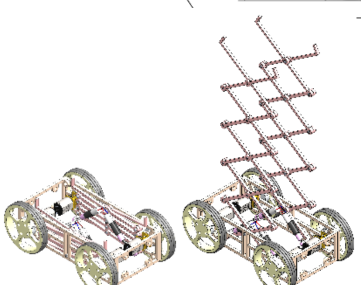


Mother Pipe Crawler

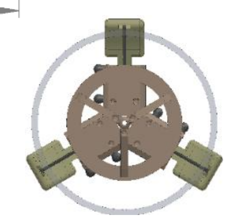
Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks



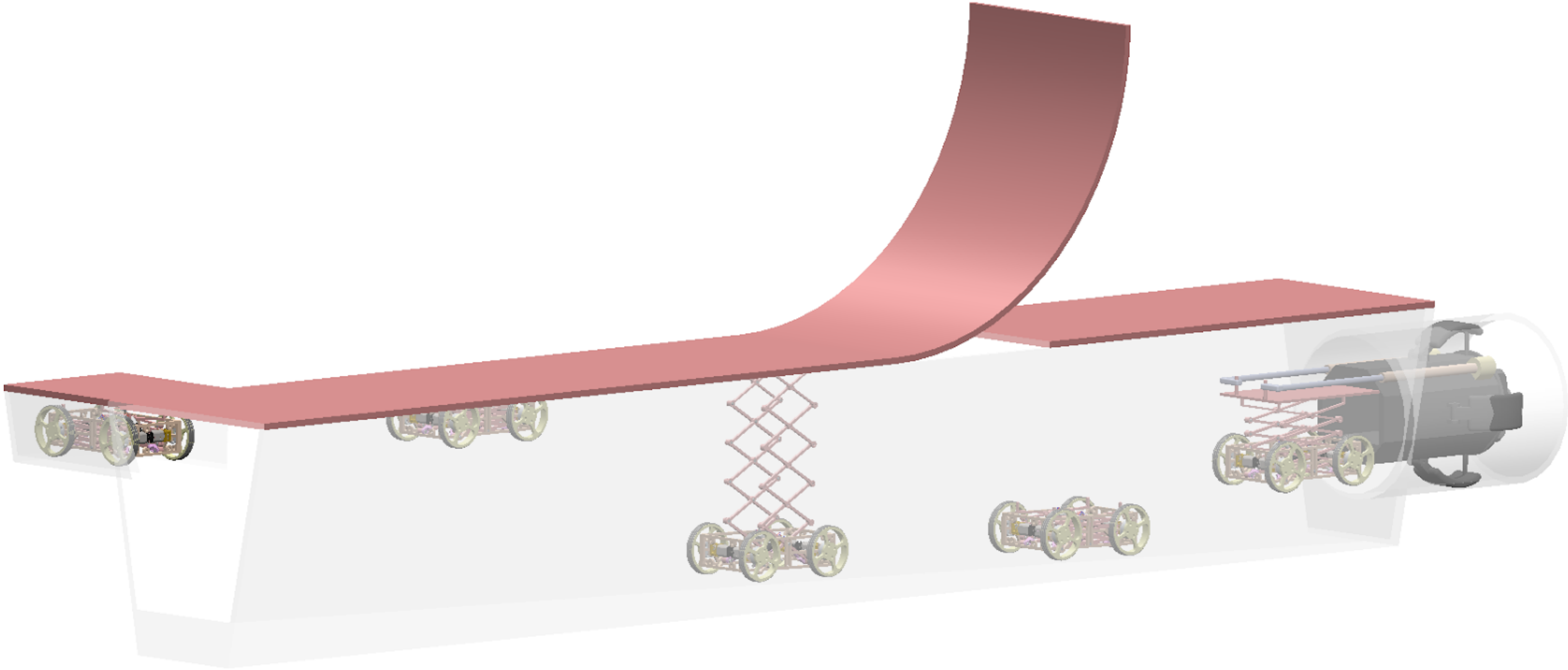


Child Inspection Rover



Task 18 - Technology Development and Instrumentation Evaluation

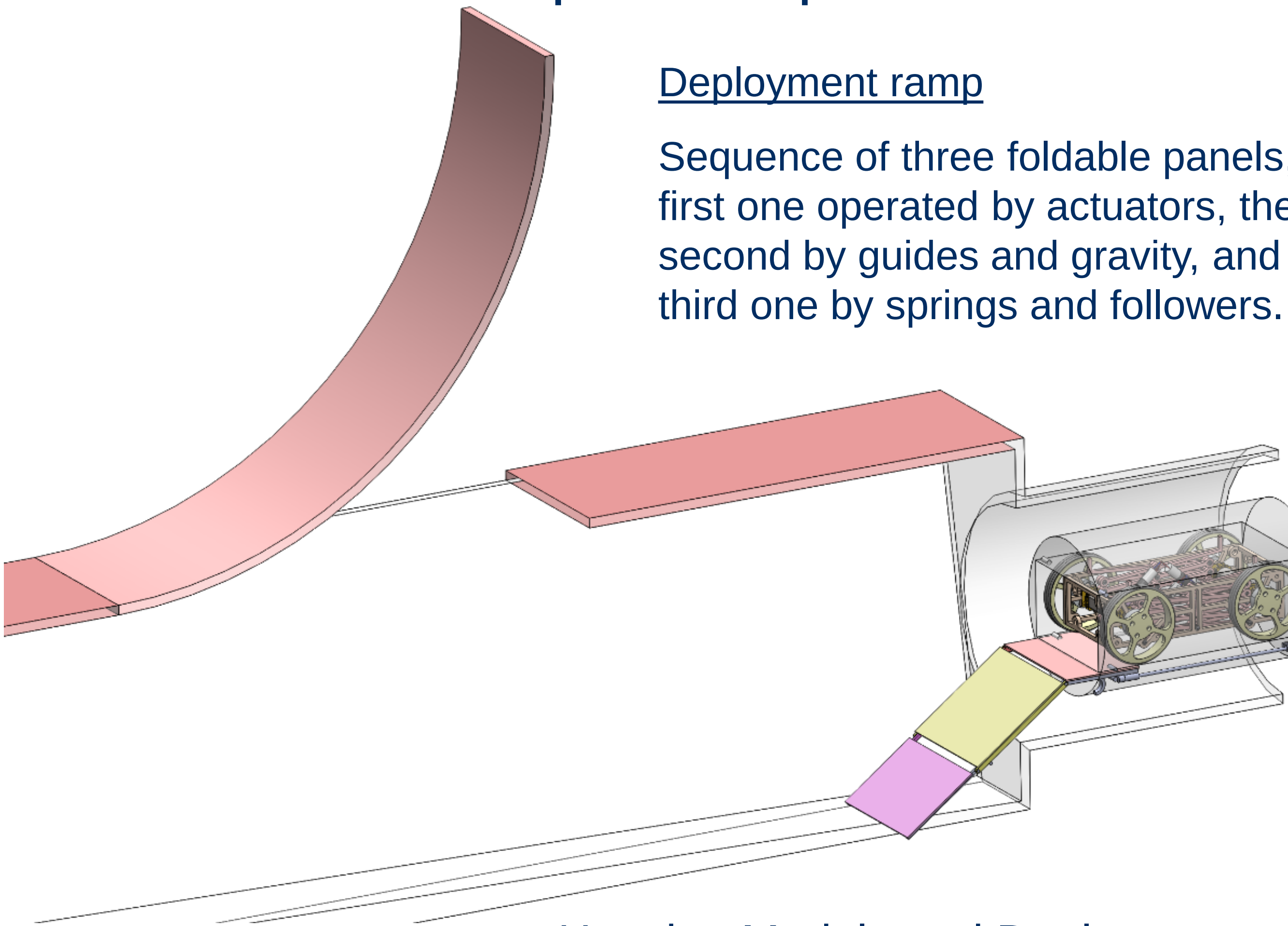
18.2 - Development of Inspection Tools for DST Primary Tanks



Housing Module and Deployment

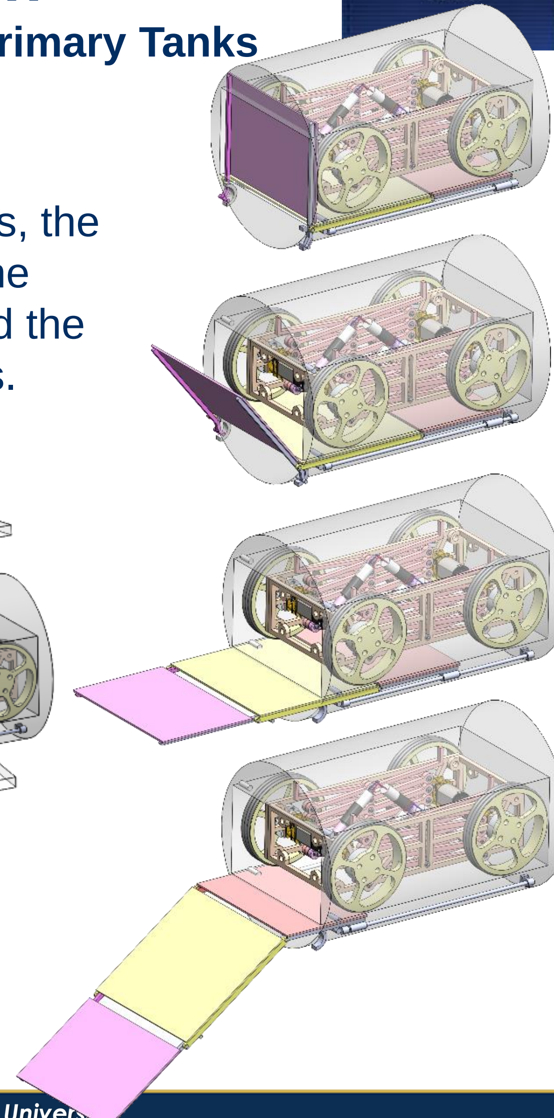
Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks



Deployment ramp

Sequence of three foldable panels, the first one operated by actuators, the second by guides and gravity, and the third one by springs and followers.



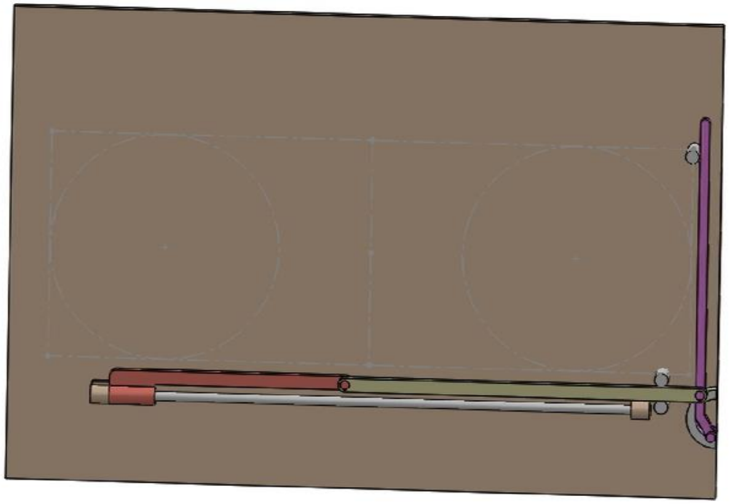
Housing Module and Deployment

Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

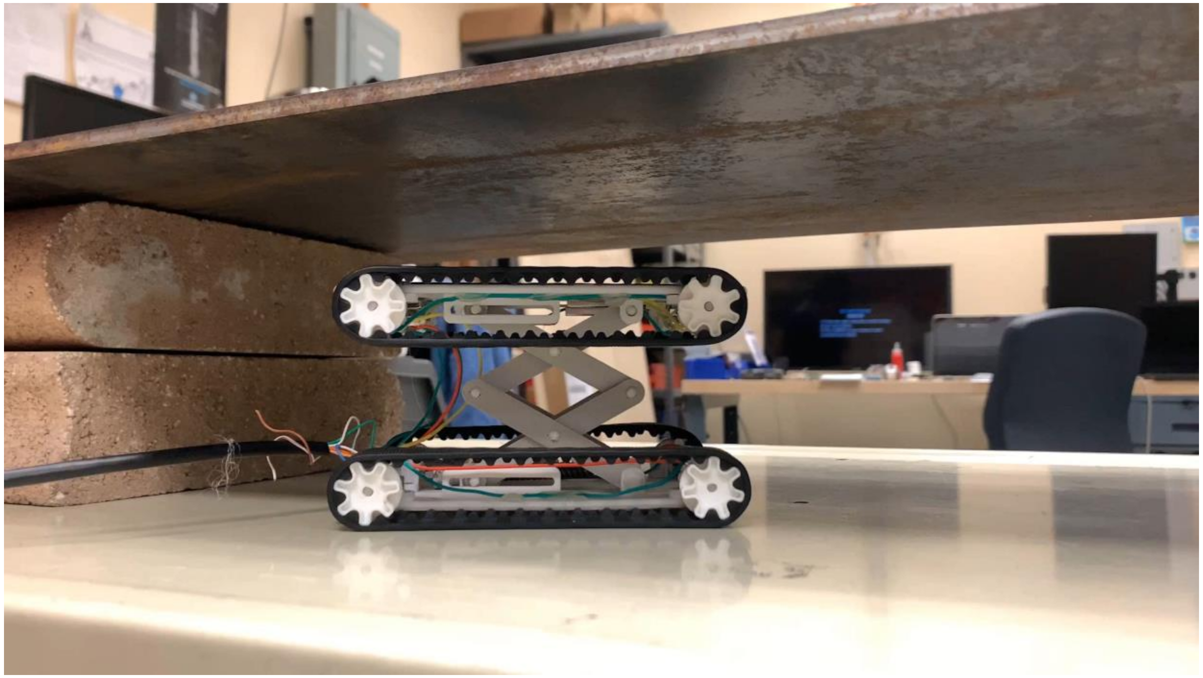
FIU Applied Research Center

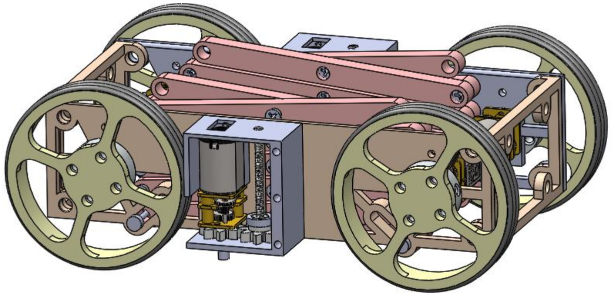
Multibody Dynamic Simulation



Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks





Drain Slot Inspection Rover

Task 18 - Technology Development and Instrumentation Evaluation

18.2 - Development of Inspection Tools for DST Primary Tanks

Proposed Scope for Performance Year 01*

Crawler

- Improve and optimize various elements of the crawler/rover system for secondary liner inspections, based on engineering scale testing.
- Incorporate a UT sensor into the rover of the system for thickness measurements.

Miniature Rover

- Deploy current system in hard to access slots at Hanford Tank Farm.
- Improve the UT sensor rover and conduct deployment tests similar to the current mini rover.
- Discuss options for potential deployment of the UT sensor rover with Hanford engineers.
- Continue the development of the 90° mini rover, incorporating sensors and testing in an engineering scale testbed.

Task 18 - Technology Development and Instrumentation Evaluation

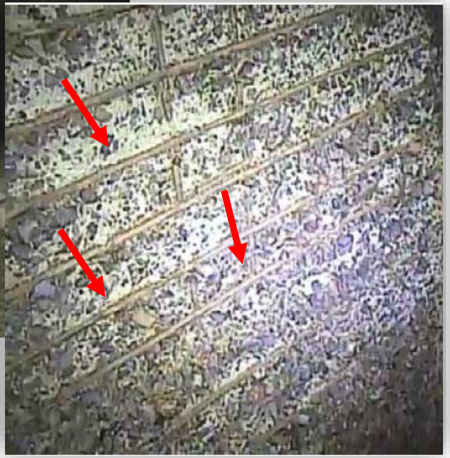
18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

<u>Site Needs:</u>

Visual inspections of the H-Canyon exhaust (HCAEX) tunnel showed degradation of the concrete walls. Also, a recent tunnel fragility analysis identified safety issues of the affected concrete regarding their strength [1].

The identification and evaluation of protective coatings to prevent further degradation of the concrete walls is necessary.

Tunnel view



Degraded concrete exposing the steel rebar (red arrows).

<u>Objective:</u>

- Develop an aging procedure to create exemplar HCEAX tunnel concrete surfaces.
- Evaluate potential coatings for future application in the HCAEX tunnel.
- Develop a robotic deployment that can navigate on the tunnel walls and apply protective coatings.

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

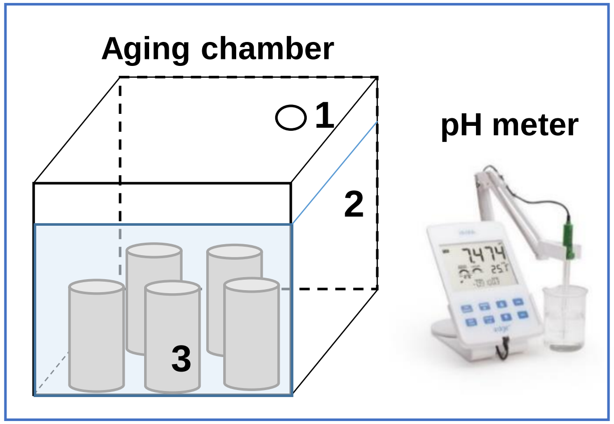
Previous Efforts

- Literature review: 1) Concrete degradation mechanisms, 2) Potential coatings for aggressive environments, 3) Accelerated aging tests and measurements for evaluating concrete/coating degradation
- Preliminary bench-scale testing for concrete aging

Results

- Degradation mechanisms were studied
- Potential coatings were investigated
- Preliminary bench-scale testing for concrete aging was developed and proposed to Savannah River site collaborators.

Aging chamber sketch



Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Current Effort: Start and complete initial bench-scale testing for concrete aging. (Standard concrete)

Materials and Methods

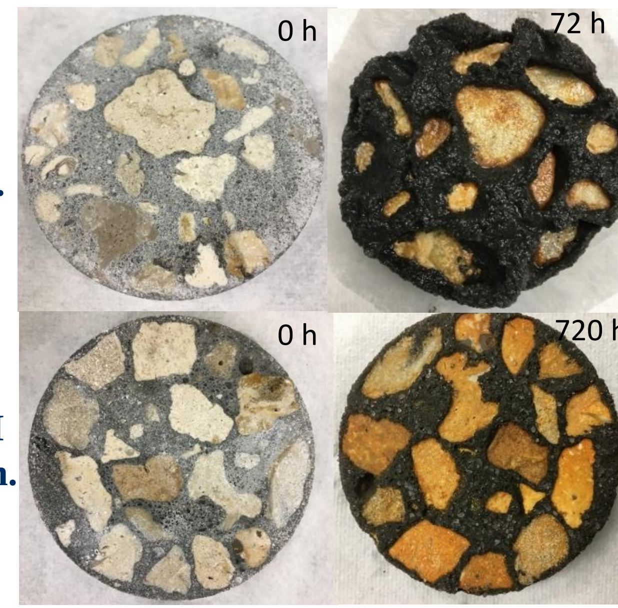
- Standard concrete
- Immersion-type test
- Two nitric acid solutions (high and low concentration)

Visual Inspection results

- Worst degradation for concrete exposed to 0.5M acid solution (high conc.).
- Coarse aggregates degraded faster than the cement paste
- Deterioration characterized by 1) loss of material 2) fragile surface, 3) pores widening, etc.

0.05M Acid Sln.

0.025M Acid Sln.



Concrete specimens immersed in 0.5 M (top) and 0.025M (bottom) acid solutions over time.

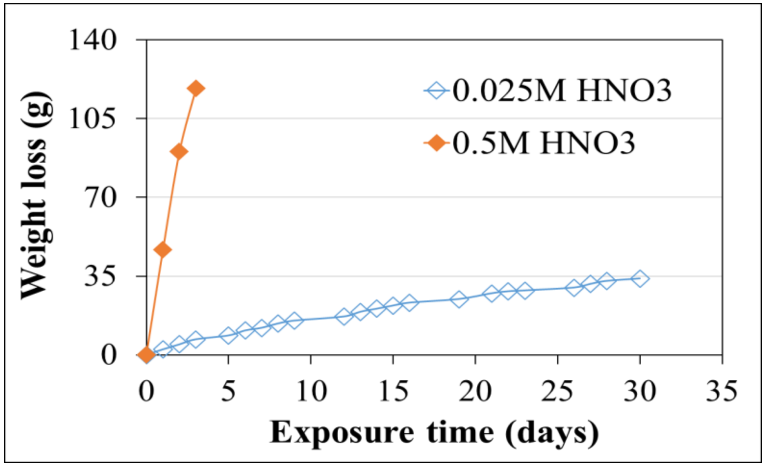
Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Applied Research Center

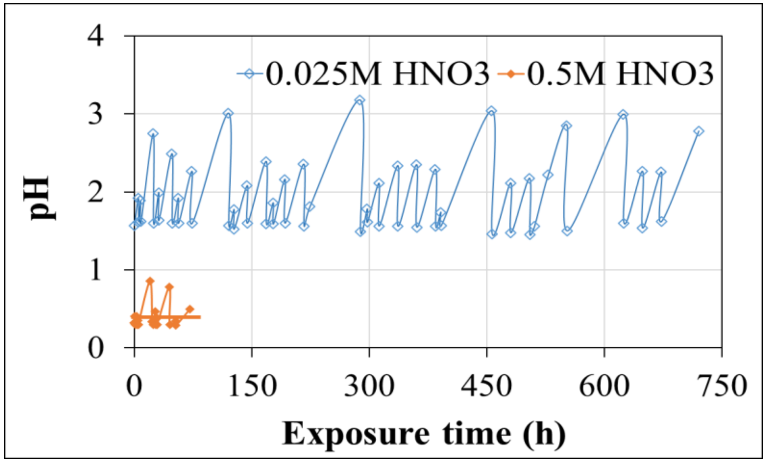
Results – Initial bench-scale testing for concrete aging (standard concrete)

Weight loss



- High conc. (0.5M): greatest weight lost (~45%) in 3 days
- Low conc.(0.025 M): slower weight loss (~13%) in 30 days

pH (test solution)



- The pH changes (solution) are shown trough the peaks out of the straight lines (0.3 and 1.6).
- pH variations were adjusted by adding concentrated acid.

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

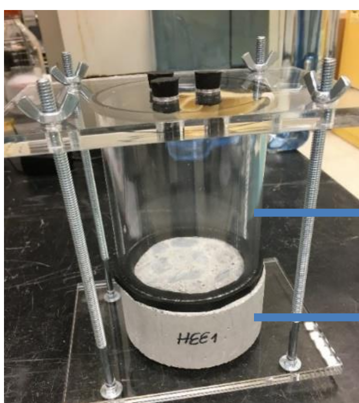
GOAL: Develop aged concrete surfaces similar to the HCAEX tunnel according to 1) Surface profile 2) Surface chemistry .

Current Effort

- Initiate bench-scale testing for concrete aging. (H-Canyon mix)

Materials and Methods

- H-Canyon concrete mix specimen preparation
- Compressive strength
- Porosity, water absorption and density



Acid solution container

Concrete specimen

New test setup for concrete exposed to acid solutions

Results

- Concrete specimens (before test) characterized
  - Water absorption, density and porosity
  - Compressive strength obtained (3625 psi) close to value reported (2500 psi) for H-Canyon concrete mix.
  - Visual inspection and images taken
- Improved test plan developed and discussed with Savannah River site collaborators.
- New test setup developed (top surface exposed, similar to the tunnel walls).

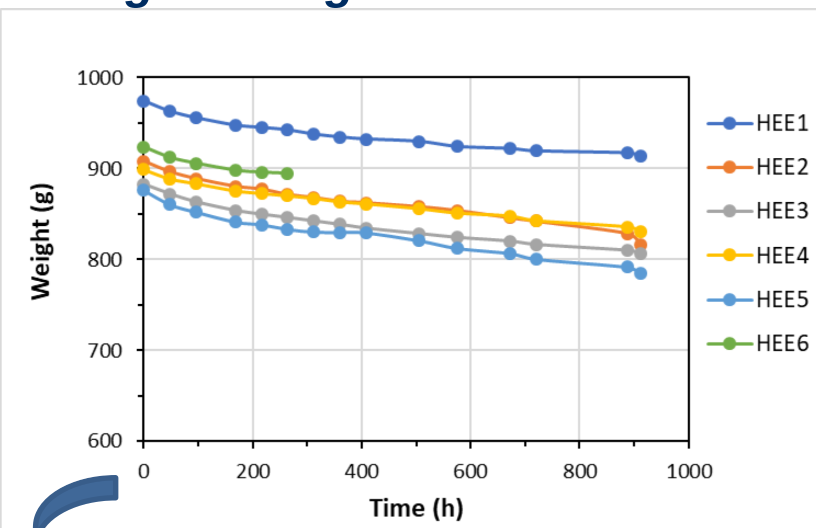
Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Results- Initial bench-scale testing for concrete aging (H-Canyon concrete mix)

Test 7: High acid concentration/enhanced aging/erosion

Weight changes



HEE1 after 38 days

- Total mass loss = 60.51 g
- % Mass loss = 6.21 %

Visual inspection

0 h | 912 h/38 d

Angle view

Zoom

Average distance of protruded aggregates (~1 in)

HEE1: replicate 1 of test 7

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Robotic Deployment Platform

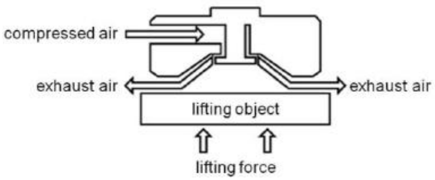
Accomplishments

- Literature review of adhesion mechanisms used on mobile platforms to traverse surfaces of varying conditions and orientation
  - Selection of a thrust/suction approach to adhesion
- Construction and testing of a mobile platform utilizing thrust as its adhesion mechanism
  - Testing of EDF (Electronic Ducted Fan) and its associated thrust force generation with a flat plate at varying distances from the inlet
  - Testing of platform prototype on wall with lateral wind speeds of up to 20 mph
  - Development of a scaled concrete wall with varying surface conditions for platform testing.
- Construction of 2-DOF mechanism with the capability of reaching any point inside of its frame design

Task 18 - Technology Development and Instrumentation Evaluation

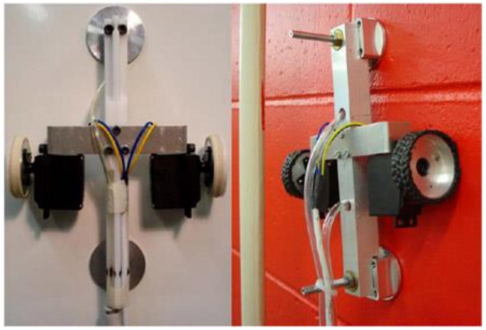
18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Completed literature review of different adhesion mechanisms that have been developed and used in traversing surfaces of varying conditions and different orientations



Non-contact surface apparatus

Non-contact surface pad adhesion mechanism



NCAP robot

Electronic ducted fan (EDF)

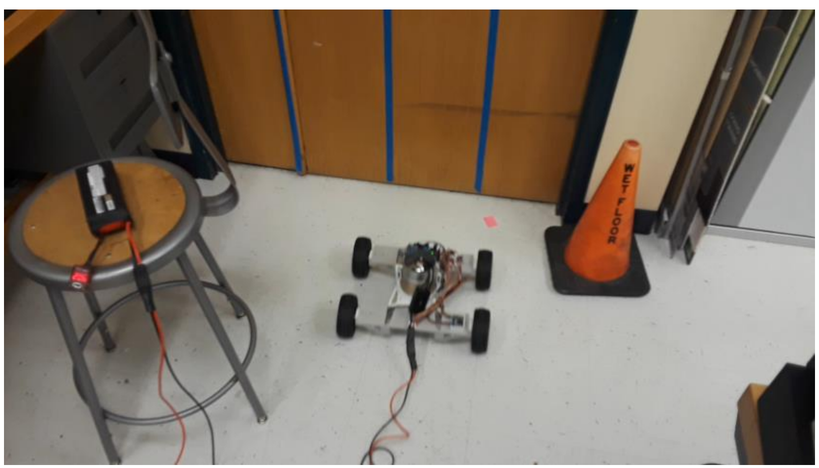
Fan based or Thrust Based Adhesion Mechanism

ETH: Zurich and Disney collaboration robot: VertiGo

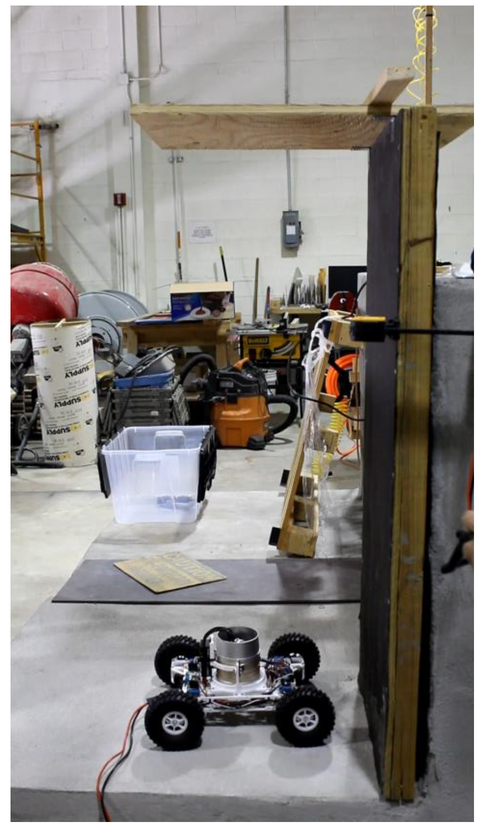
Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

- Constructed scale mockup of concrete wall to test platform
- Thrust based surface adhesion tested on different surface conditions
- Platform can perform multiple orientation changes while maintaining surface contact



Testing of prototype 1 in robotics lab



Testing of platform prototype 1 and 2 on concrete wall mock-up

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Platform Testing with Wind

- During potential times for deployment at H-Canyon, winds speeds have been reported to reach 25-30 mph with the single exhaust fan in operation
- The mobile platform was tested by exposing the unit to wind speeds of up 20 mph
- Orientation of unit did not effect its ability to adhere to surface when exposed to wind speeds
- The red strap pictured in the images was used as a safety harness in case the unit loss power

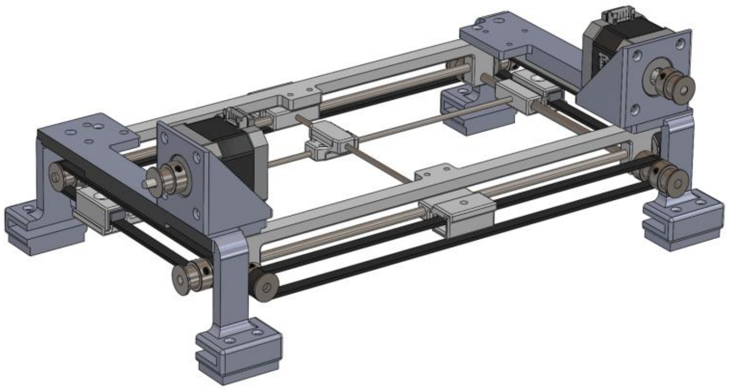
Prototype 1 under wind speeds

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Design Concept of X-Y Spraying Mechanism

- Designed using a guide rail system that will allow center component to have 2-DOF in a plane
- A belt system will be used to transmit necessary power to move center module to desired location
- Designed to be modular, the mechanism can easily be modified to fit a chassis of varying dimensions



CAD model of 2-DOF mechanism

Prototype of 2-DOF mechanism being test

Task 18 - Technology Development and Instrumentation Evaluation

18.3 – Evaluation of coatings for the H-Canyon exhaust tunnel

Proposed Scope for Performance Year 01*

- Continue bench-scale testing of concrete specimens exposed to accelerated aging conditions similar to the H-Canyon Exhaust tunnel environment:
- Conduct bench-scale testing of potential coatings submitted to accelerated aging conditions:
  - Selection of potential coatings for bench-scale testing.
  - Application and evaluation of the selected coatings applied on the aged and non-aged developed concrete surfaces.
- Design of key of tasks for spray mechanism needed to replicate the coating results similar to those obtained from industry protocols
- Augment the platform design by increasing the coverage
- EDF blade testing and damage quantification along with performance analysis
- Complete design of spray mechanism and integrate into platform

Task 18 - Technology Development and Instrumentation Evaluation

Site	Technology	2020	2021	2022	2023	2024
DST Hanford		In-house Deployment	Site Deployment			
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
DST Hanford		Evaluation	In-house Deployment	Site Deployment		
H Canyon SRNL		Conceptual Design	Sensor Integration	Evaluation	In-house Deployment	Site Deployment
WIPP		Evaluation	In-house Deployment	Site Deployment		
LM Site		Evaluation	In-house Deployment	Site Deployment		

Task 19 - Pipeline Integrity and Analysis

19.1 - Pipeline Corrosion and Erosion Evaluation

Site Needs:

Due to uncertainties regarding the structural integrity of pipelines at Hanford, a Fitness-for-Service (FFS) program for the Waste Transfer System has been implemented.

A direct inspection and assessment of the condition of buried pipelines is required to evaluate the corrosion and erosion wear rates to predict the existing system's remaining useful life.

Thickness and Leak detection technologies

Objectives:

- Evaluate alternative approaches for real-time thickness measurements, wear rate and leaks in pipes and waste transfer lines.
- Evaluate technologies that can be used to assess the integrity of pipelines.

Task 19 - Pipeline Integrity and Analysis

19.1 - Pipeline Corrosion and Erosion Evaluation

Previous Efforts:

- Evaluation of Permasense Ultrasonic Sensor Systems
- Engineering Scale testing

Erosion Test Loop:

- 4 Permasense guided wave sensors
- 2 and 3 inch pipe sections (straight sections and elbows)
- Sand/water mixture
- 3 HP centrifugal pump - up to 2.5m/s and 110 gpm
- Sand particle sizes - 400 to 1600 microns
- By-pass system to control flow rates

Test Loop

Task 19 - Pipeline Integrity and Analysis

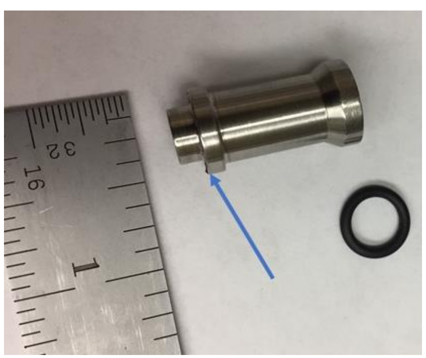
19.1 - Pipeline Corrosion and Erosion Evaluation

SRNL Erosion Coupon and UT Probe System

Current Effort

- V260-SM
- Delay Line Transducer
- 15 MHz Frequency
- 0.125 in. Element Diameter

Olympus UT sensor

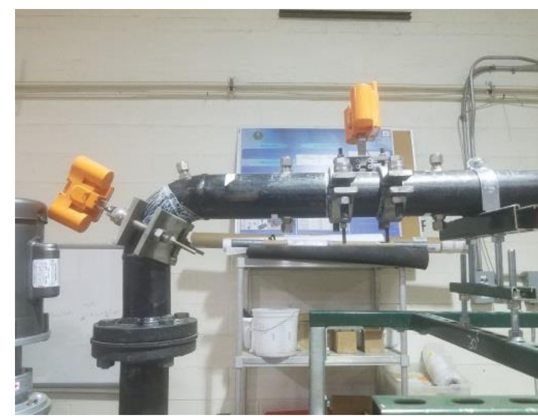


SRNL coupon

Purpose

- Incorporate an additional method to measure sensitive wear rate
- Shorten the test durations
- Provide a correlation between UT sensor data and mass loss data

Thickness measurements using UT probe



Coupons on the pipe loop

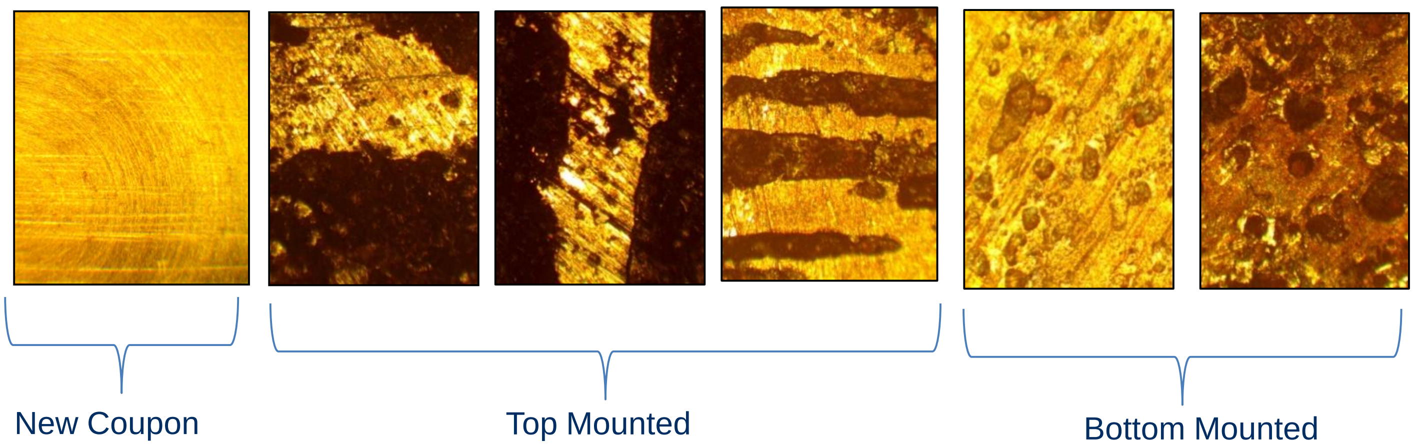
FIU Applied Research Center

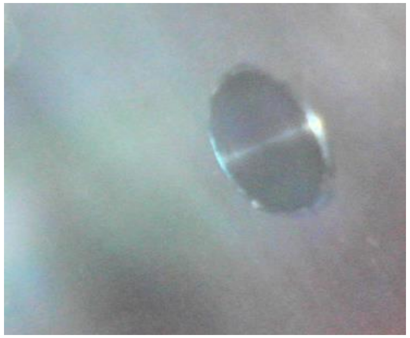
Task 19 - Pipeline Integrity and Analysis

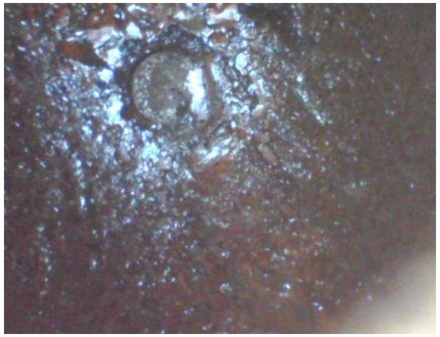
19.1 - Pipeline Corrosion and Erosion Evaluation

<u>Current Effort</u>

SRNL Coupon Surface Images (Microscope and Borescope)







Under magnification, pit morphology becomes clear and shows unique relationship between erosion and placement on pipeline

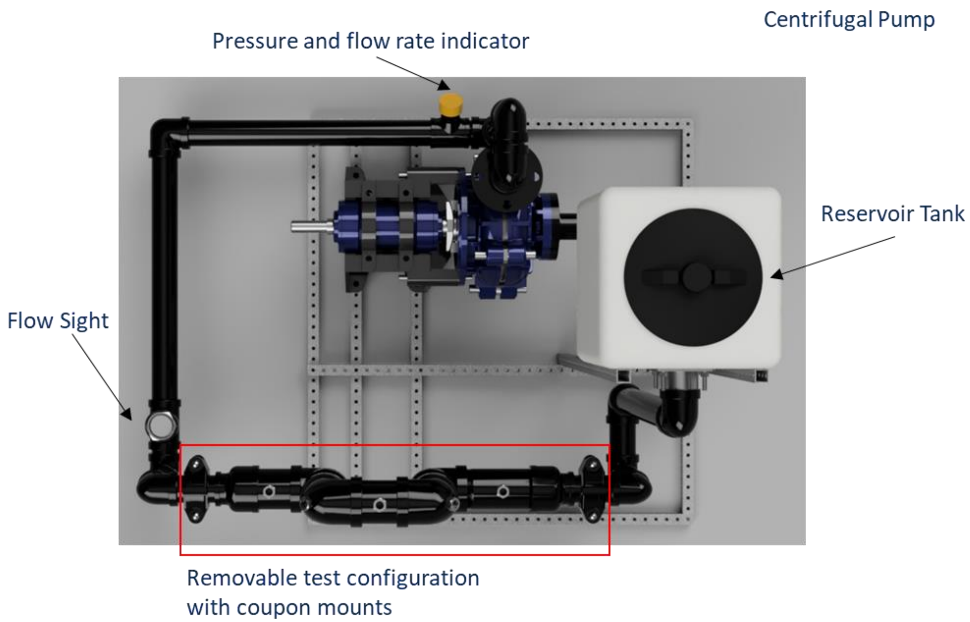
Task 19 - Pipeline Integrity and Analysis

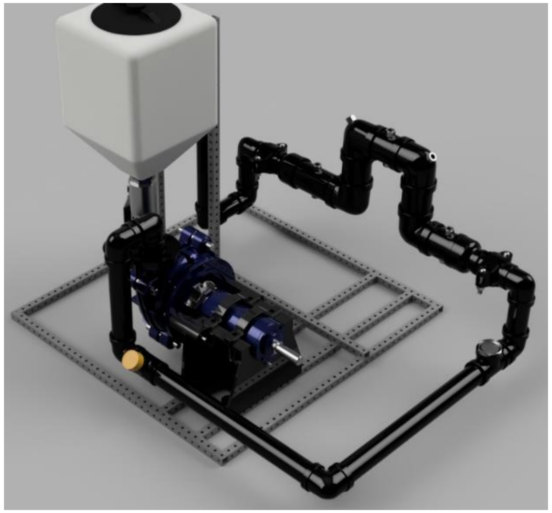
19.1 - Pipeline Corrosion and Erosion Evaluation

Current Effort

Design of New Erosion Loop

- Bench top unit - portable
- Caustic simulants, Stainless steel material
- 3-inch pipe sections (straight and elbows)
- Test erosion, corrosion and mass loss in coupons
- Flexibility to test a variety of materials





Task 19 - Pipeline Integrity and Analysis

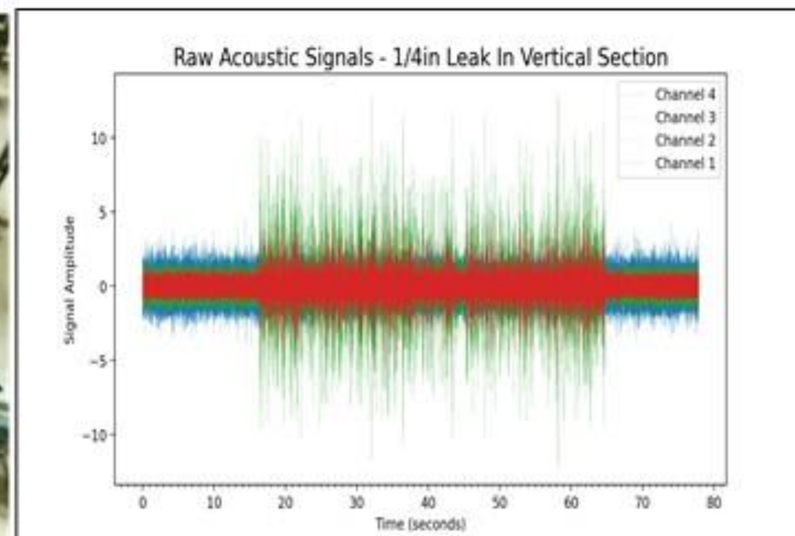
19.1 - Pipeline Corrosion and Erosion Evaluation

Current Effort **Leak detection in pipes using Fiber Optic Sensors**

Deploy a combination of fiber optic and electroacoustic technologies to accurately identify the location of a pipeline leak or crack.

Fiber optic sensors installed on the pipe loop

- 4 Sensors
- Diameter – 4in
- Thickness – 0.75 in



Task 19 - Pipeline Integrity and Analysis

19.1 - Pipeline Corrosion and Erosion Evaluation

Proposed Scope for Performance Year 01*

- Construct the proposed bench scale pipe loop with modular sections.
- Continue testing the SRNL mass loss coupons using realistic simulants.
- Conduct material tests on eroded pipe sections and SRNL coupons.
- Automate the leak detection and leak location process of CEL fiber optic sensor systems.
- Use the experimental sensor data to develop machine learning models and predict the remaining useful life of tanks and transfer system components.

Task 19 - Pipeline Integrity and Analysis

19.2 - Evaluation of Nonmetallic Components in the Waste Transfer System

FIU Applied Research Center

Site Needs:

Nonmetallic materials are used in the US DOE's Hanford Site Tank Farm waste transfer system. These include inner primary hoses in the HIHTLs, Garlock® gaskets, EPDM O-rings, and other nonmetallic materials.

Nonmetallic materials are exposed to β and γ irradiation, caustic solutions as well as high temperatures and pressure stressors. How they react to each of these stressors individually has been well established, but simultaneous exposure of these stressors is of great concern.

Objectives:

- Provide the Hanford Site with data obtained from experimental testing of the hose-in-hose transfer lines, Garlock® gaskets, EPDM O-rings, and other nonmetallic components under simultaneous stressor exposures.
- Due to experimental testing location limitations, no radiation exposure testing will be conducted.

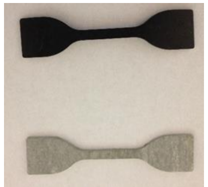
Task 19 - Pipeline Integrity and Analysis

19.2 - Evaluation of Nonmetallic Components in the Waste Transfer System

FIU Applied Research Center

Previous work:

- Recent studies have involved aging of nonmetallic materials in a NaOH solution.
- Material tested included:
  - Hose-in-hose transfer line (HIHTL) inner hose
  - EPDM and Garlock® dog-bone coupons



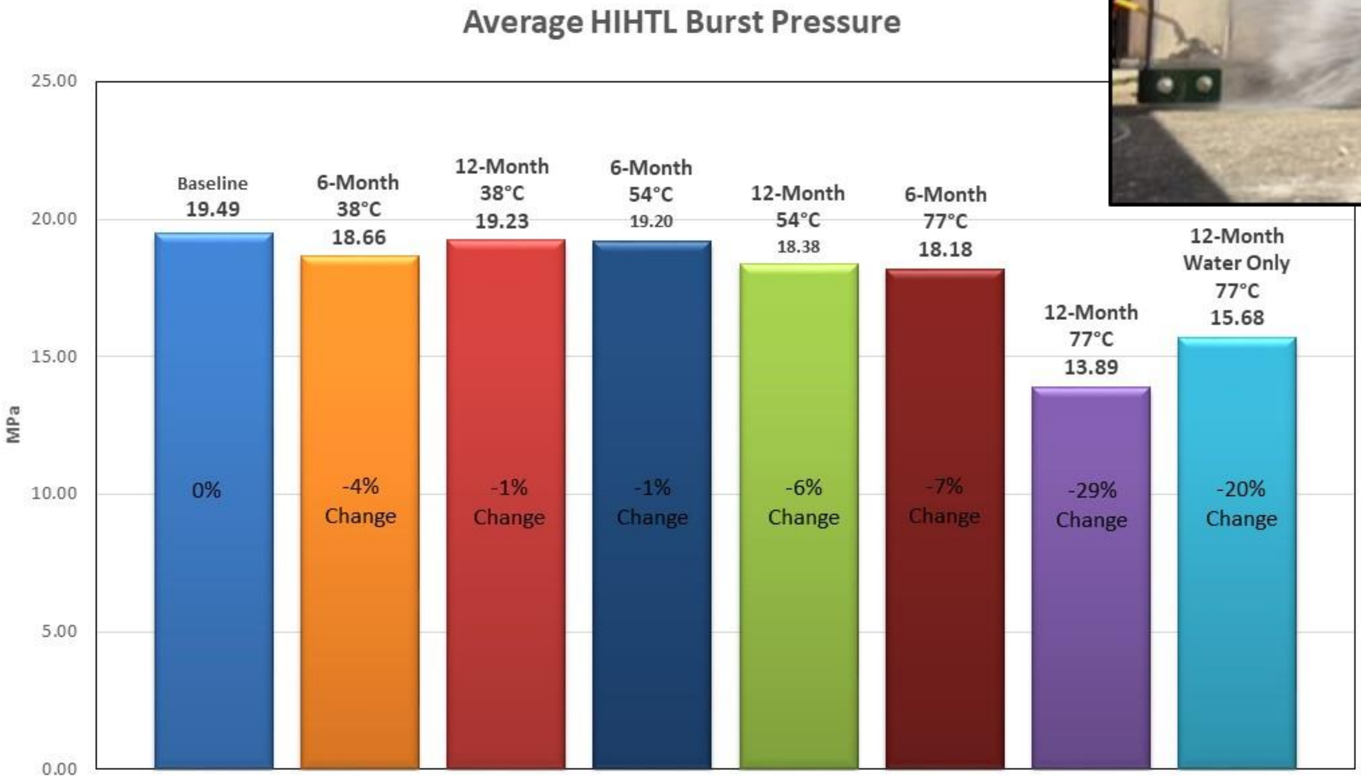
- Each material sample was "aged" by exposure to a 25% sodium hydroxide solution at 100˚F, 130˚F and 170˚F for a durations of 180 and 365 days.
- In addition, material samples were aged by exposure to only water at 170°F for 365 days.
- After aging, the mechanical/material properties of the samples measured and compared to unaged samples to identify any degradation in the properties.
- Hose burst pressure as well as material tensile strength test were conducted.

Current work:

- Evaluated mechanical/material properties of samples aged with only water and compared to unaged samples and samples aged with NaOH to identify any degradation in the properties.
- Evaluated hose and material dog-bone samples aged with only water using a scanning electron microscope with energy dispersive X-ray spectroscopy (SEM-EDX) to determine if there is a correlation between elevated temperature exposure and material degradation.

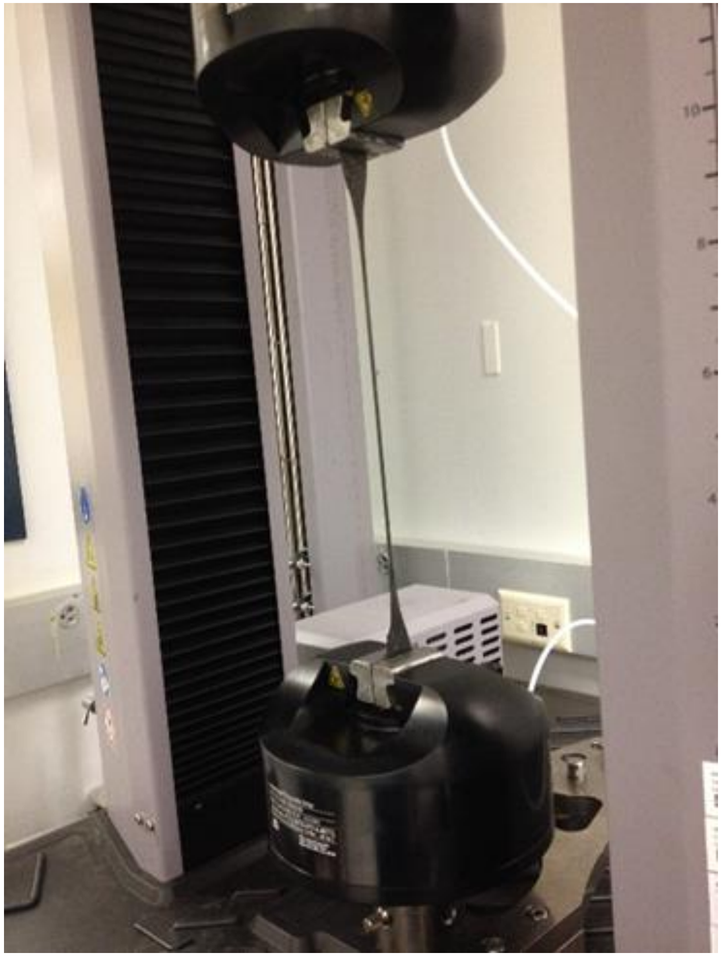
Water-Only HIHTL Pressure Testing

- Specimens were pressurized until rupture.
- Pressure profiles and initial and final lengths were measured.
- Rupture pressure was compared to baseline values.

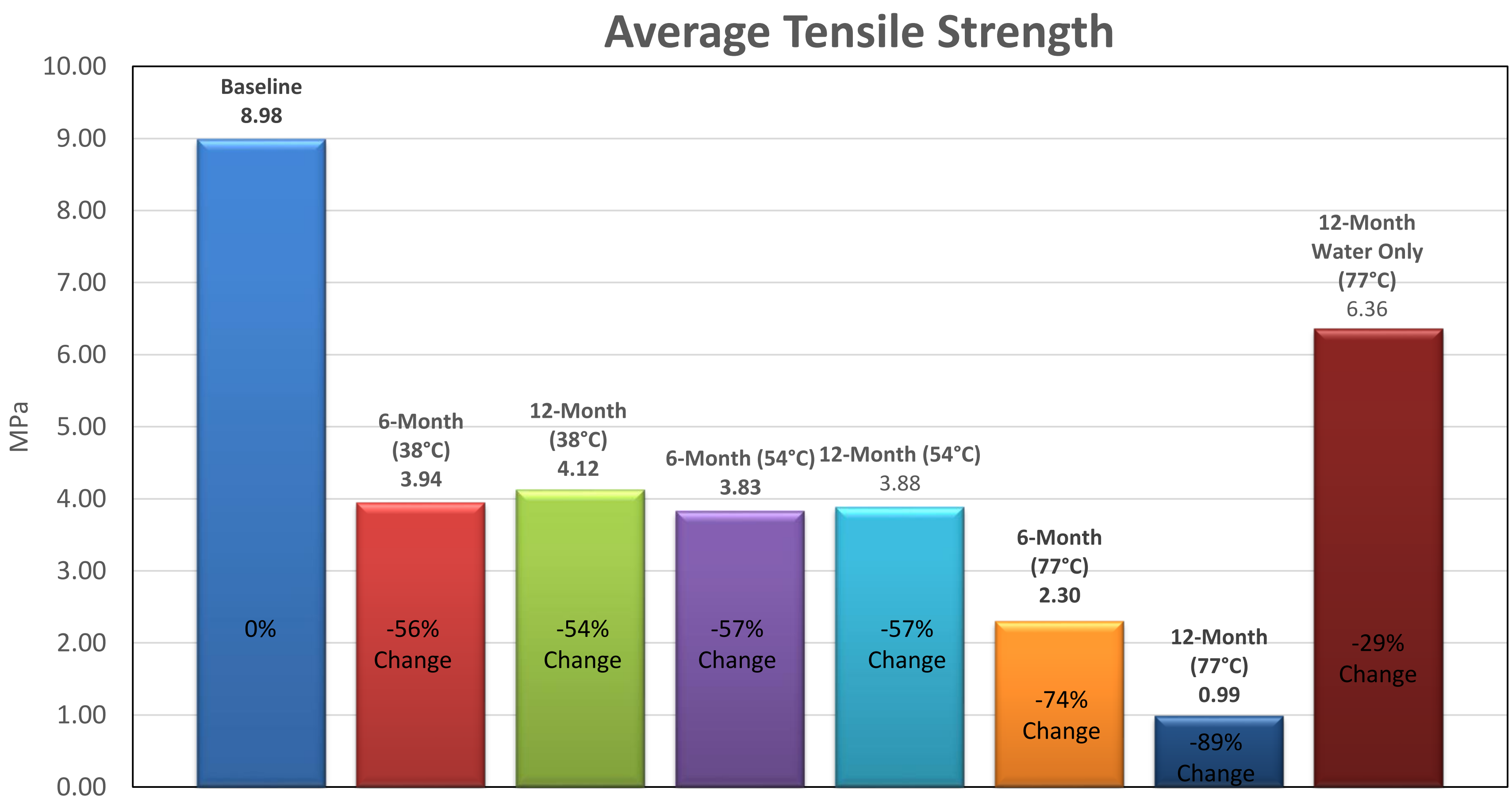


EPDM Material Testing

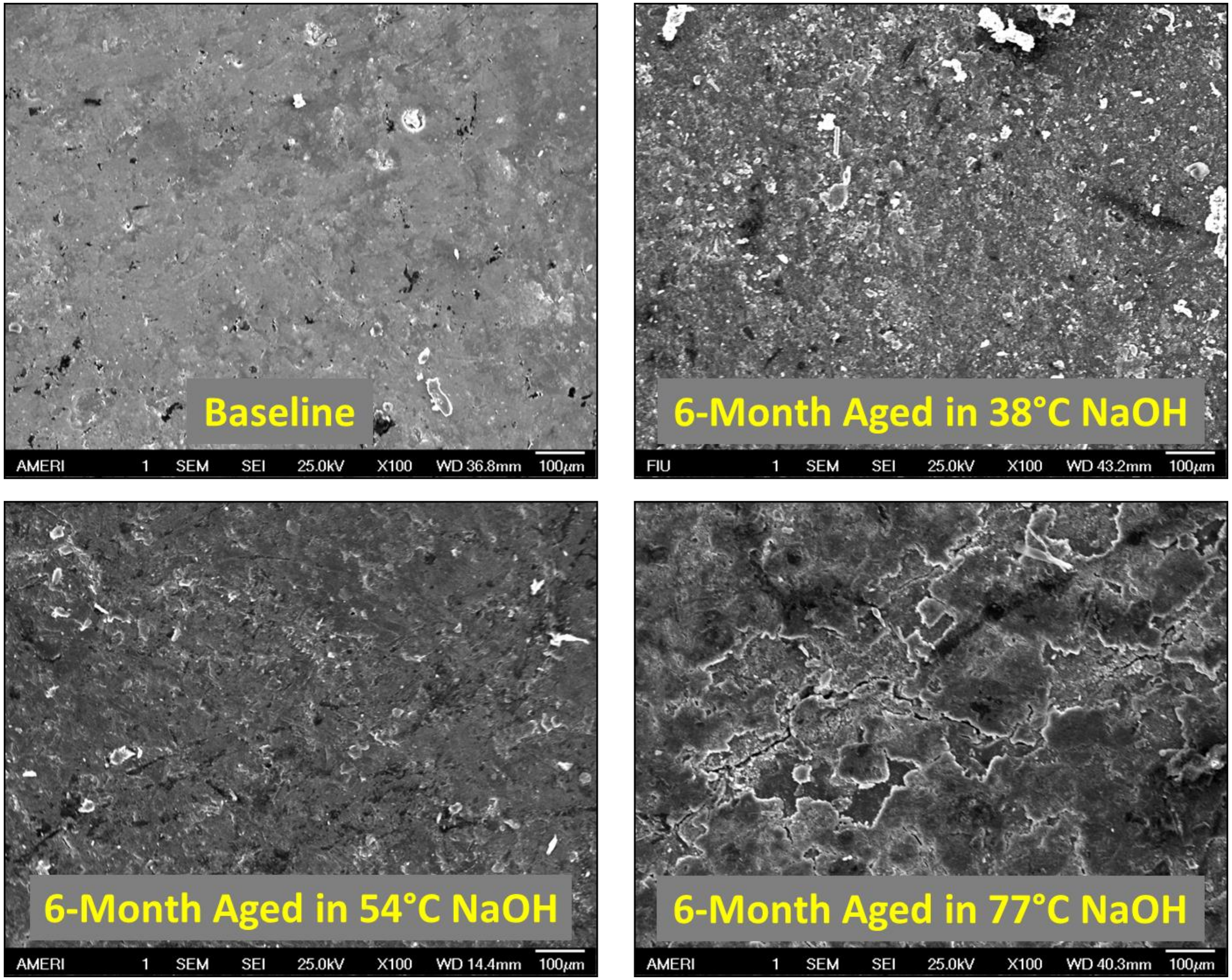
- The water-only aged EPDM dog-bone specimens had their tensile strength tested and compared to the baseline results.
- All procedures used for testing were derived from the ASTM D412-16 standard.
- Tensile strength tests for the dog-bone samples were conducted on an MTS Criterion™ Model 43 with an accuracy of ±0.5%.



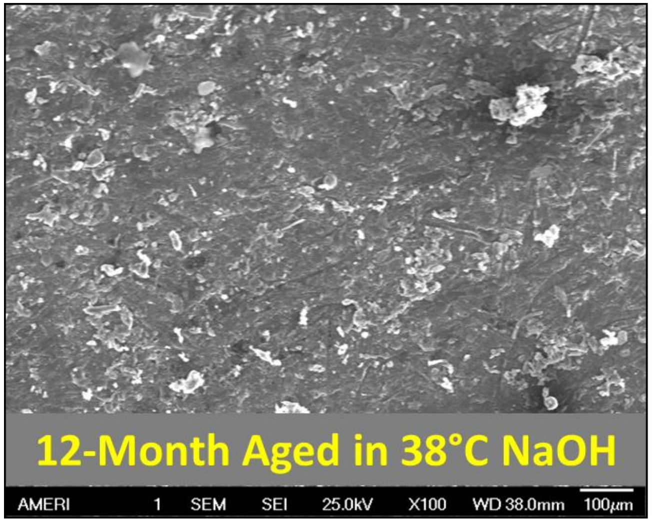
EPDM Material Testing

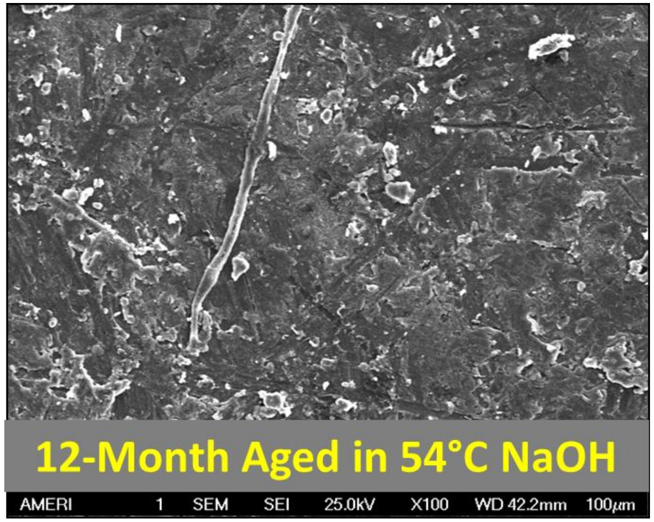


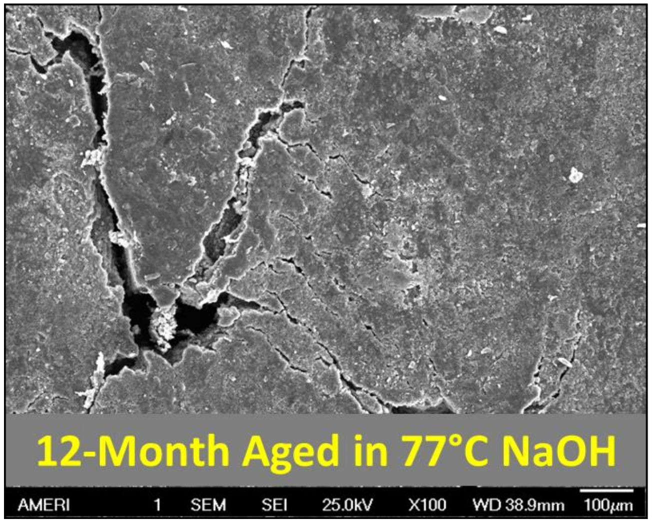
SEM Scan of 6-Month Hose Inside Surface



SEM Scan of 12-Month Hose Inside Surface







Phase III Aging Loop

- In order to determine the effect of the NaOH on the material degradation, aging experiments are being conducted with four loops of 6.25%, 12.5% and 25% NaOH and only water respectively running at 170°F.
- The setup consists of four pumping loops with three hose sections on each loop.
- The coupon aging consists of a coupon aging vessel submerged in the test loop's storage tank with each vessel containing six EPDM dog bone samples.

Proposed Scope for Performance Year 01*

- Complete one-year phase III aging of hose and dog bone specimens.
- Conduct burst pressure tests, material tests and SEM analysis
- Evaluate results with Hanford engineers and develop life expectancy model for material under load.