Internal Quarterly Report

Date of Report: 5th Quarterly Report – January 4th, 2023
Contract Number: #693JK3211RA0001
Prepared for: PHMSA DOT
Project Title: Assessment of Nondestructive Examination (NDE) and Condition Monitoring Technologies for Defect Detection in Non-Metallic Pipe
Prepared by: EWI
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For quarterly period ending: December 31, 2022

1: Items Completed During this Quarterly Period:
The fifth quarterly update was completed during Quarter five. Additional pipes June 20th and June 24th, those pipe details were added to the matrix

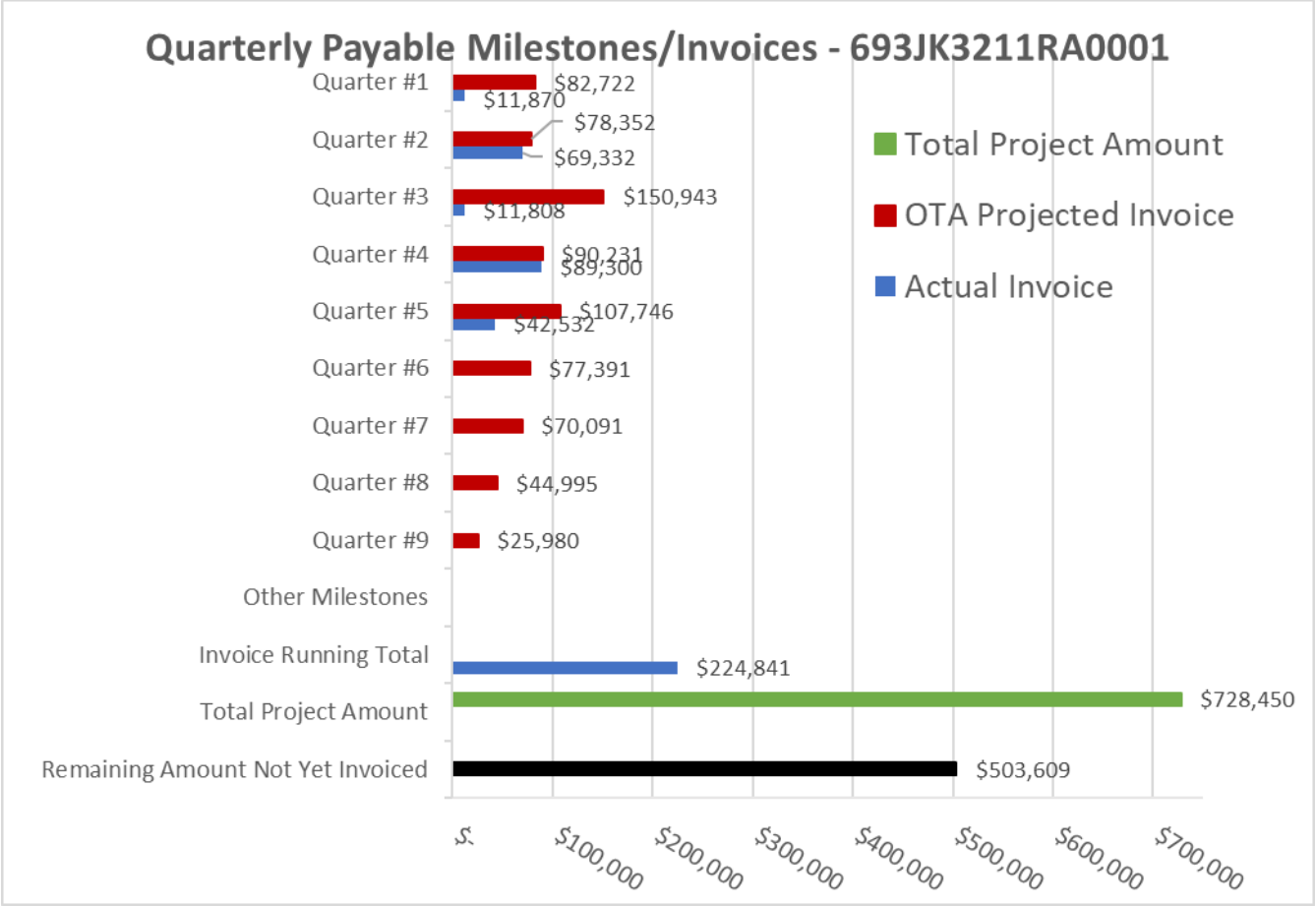
Item #	Task #	Activity/Deliverable	Title	Federal Cost	Cost Share
11	10	Submit 5th Quarterly Report	5th Quarterly Status Report & Quarterly collaboration meeting	$11,990.81	0.00
3	2	NMP sample matrix detailing type of pipe and defects, anomalies, or damage per sample	Prepare detailed matrix of NMP samples	$30,540.73	$66,782.84

2: Items Not Completed During this Quarterly Period:
EWI drafted the NDE procedures for all the internal methodologies and is awaiting the drafted procedures from our external subcontractors for AirCoupled UT and Microwave Array. EWI is working to obtain their NDE procedures and coordinate pipe inspections.
Erosion testing is ongoing as EWI adjusts parameters due to test results and materials.

Item #	Task #	Activity/Deliverable	Title	Federal Cost	Cost Share
4*	3	Develop NDE procedures for inspection of NMP samples using non-contact and 3 coupled UT methods, microwave inspection method and 2 thermography methods	Completion of written NDE procedures	$49,331	$20,310
10*	6	Task report summarizing erosion test procedure and results, and NDE inspection results	Perform inner liner erosion tests & assess NDE detection	$95,755.10	$1,832.84

3: Project Financial Tracking During this Quarterly Period:
The actual spend is behind planned.

- Task 3 – EWI has drafted NDE procedures. Our requests for quote for Microwave Imaging and Air Coupled UT were sent in April, after addressing several questions we received multiple no bids and what bids we did receive were six times larger than the bids these same companies provided during our 2021 proposal process. EWI has done their due diligence to reach back out to companies who have now agreed to bid and received quotations back. EWI is now awaiting our first deliverable from the subcontractors: drafted procedures for both AirCoupled and Microwave Array EWI will finalize procedures including both internal NDE testing procedures.



4: Project Technical Status –

Item	Task	Activity/Deliverable	Title
1	10	Submit 1st quarterly report	1st Quarterly Status Report & Quarterly collaboration meeting
2	**1**	Task report summarizing findings of literature review	Literature review of recent research on NDE of polymers & composites - issue task report
3*	2	NMP sample matrix detailing type of pipe and defects, anomalies, or damage per sample	Prepare detailed matrix of NMP samples
4*	3	Develop NDE procedures for inspection of NMP samples using non-contact and 3 coupled UT methods, microwave inspection method and 2 thermography methods	Completion of written NDE procedures
5	10	Submit 2nd Quarterly Report	2nd Quarterly Status Report & Quarterly collaboration meeting
6	6	Task 6 Test Procedures and Chamber Assembly	Prepare & Provide a Written Test Procedure for Erosion Tests
7	4	NDE Review Progress to date (samples. procedures, early inspection data)	Task 4 NDE Project Review
8	10	Submit 3rd quarterly report	3rd Quarterly Status Report & Quarterly collaboration meeting
9	10	4th Quarterly Status Report	4th Quarterly Status Report & Quarterly collaboration meeting
10	6	Perform inner linear erosion tests & assess NDE detection	Task report summarizing erosion test procedure and results, and NDE inspection results
11	10	5th Quarterly Status Report	5th Quarterly Status Report & Quarterly collaboration meeting
28	10	Annual Review	Review Meeting (virtual)

Task 1 – Literature Review was completed by EWI and NDE4zero's Mark Lozev. The report was supplied to the project team on 3/31/2022
Task 2 – NMP Sample Matrix. EWI received additional pipes in late June and is updated the Matrix

Task 3 – The internal NDE procedures have been developed. NDE procedures for external technologies is awaiting procurement activities.
Task 4 – CT scanning was completed in mid-June on pipe samples that had been received by the project at that time. New pipe samples were received late summer 2022 and CT scanning was completed in December 2022. EWI NDE has begun testing selected pipe samples from this batch of material. The NDE testing, and analysis is underway, data and images were shared at the Q4 meeting on 9/21/22 and Q5 meeting on 12/16/2022. Testing will continue for several months with EWI completing multiple forms of NDE and then sending pipe to subcontracts for additional methods (air coupled UT and Microwave). Current NDE Testing and CT scanning Summary:

- Immersion UT Conclusions:
    - ID and OD layers can be inspected individually, but core layer has not been detected due to gaps between each material
- Immersion UT Next Steps:
    - Immersion UT of well bonded pipes after CT

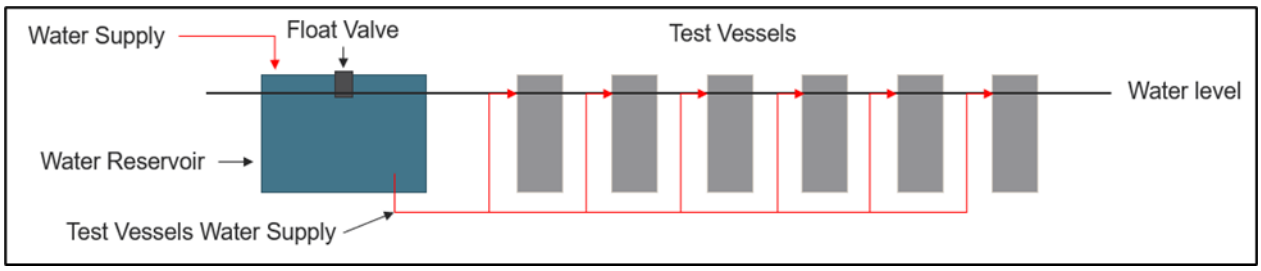
- Thermography Conclusions:
    - Surface markings impact heat transfer observations - Glue from tape and razor marks along pipe obstruct any identification of ID holes or end drilled holes
    - Clean areas are more easily inspected, however only the outer layer has been observed due to gaps between layers preventing sufficient heat transfer
- Thermography Next Steps:
    - Modified heat sources – longer heating times using halogen lap on pipe interior and exterior

Task 6 – The cost share portion of this task has been completed (Item #6 Task 6): test cells have been built and a test method developed (5/31/2022). The task began in December 2021 and has been completed in June 2022. The federally funded portion of this work began in August 2022. Tests are currently being run and will be billed under item #10 Task 6. The weeklong erosion trial has ended and EWI found that the sand polished the internal diameter of the pipe, the sharp leading edges of the impeller were dulled, so its lifetime may only be several months before replacement is necessary, and finally the sand did not stay suspended well in the water. It was found to be mostly packed on the bottom. EWI has experimented with less sand (lower concentration) and/or smaller particle size to mitigate these concerns in additional trials. The right concentration and particle size should replicate the conditions of West Texas and determine effect of erosion on the inside of NMP during normal use. This controlled process will allow the creation of a model that will be used to predict the use life of NMP and also help to identify NDE techniques to detect erosion on the inside walls of the pipe.

Initial NDE techniques are used to get baseline measurements of the pipe from both the inside and outside. The location that the NDE is performed is marked along the length of the pipe, this is the side of the pipe that the mixing blade will be located near to maximize erosion. Along the side where NDE was completed, abrasion marks are made to the inner wall of the pipe from top to bottom. This is done to be able to have a visual indication that wear is occurring, the area adjacent to the abraded area will also be documented with images. A borescope is used to take images at 3 locations, low in the pipe near the mixing blade, in the center of the pipe, and at the top of the pipe. The abraded inner surface allows for easier visual indication that erosion is occurring and creates a worst-case scenario for the testing. Referencing the location of the images is important so that repeat images can be taken as testing progresses.

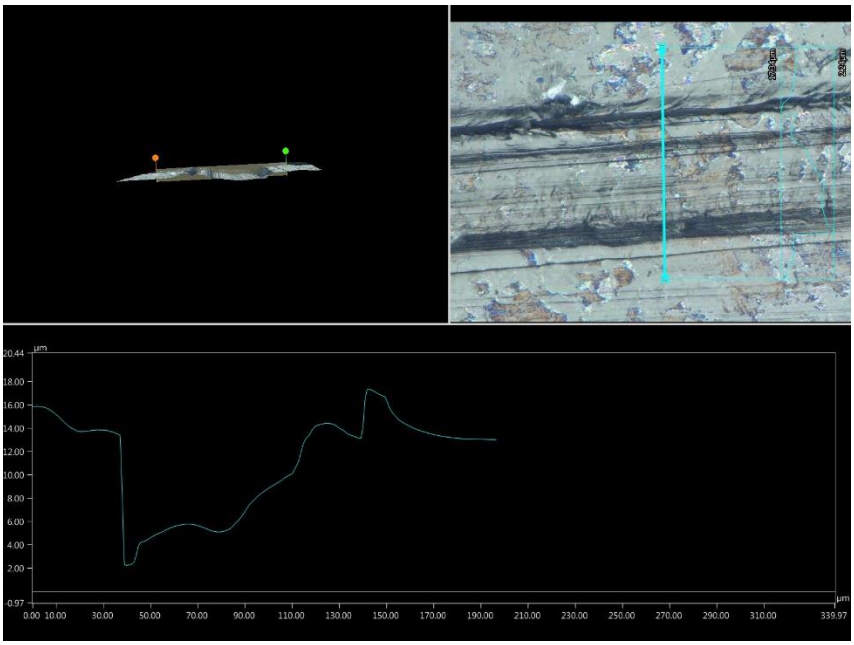
Several abrasion techniques were tried to determine what would create the best surface for visual inspection for erosion. Creating vertical gouges, localized Dremel sanding wheel, sharpie marker marking, and using 60 grit sandpaper to abrade vertically from top to bottom were tried on the interior surface for wear indication. After a 1-week initial test, the sand paper abrasion showed a larger difference due to increased surface area compared to the other techniques. It was noticed that in the abraded area, as well as the non-abraded area, surface polishing was occurring during the test. This is a good indication that there may be quantifiable erosion results at the end of the longer duration tests.

During the initial set up trials, it was noticed that evaporation of the water from the test pipes during the tests was an issue. In the heated tests, approximately 2/3 of the water was evaporating over night. To combat this, an automatic water leveling system was set up using a float valve in a supply tank, so that the water level in each test station would be automatically maintained throughout the duration of the test.



During the 8–10-week test period for each test pipe, the test stations will be monitored daily for water level, sand distribution, and temperature. Discrepancies will be noted and resolved as needed. At a minimum of every two weeks during the test, the test stations will be shut down emptied for inspection and borescope images taken. By having a series of images taken throughout the test we will be able to document the wear over time.

At the conclusion of the tests, final NDE will be performed in the same locations and by the same techniques as the original scans. Detailed analysis will be done to determine if change has occurred in the wall thickness or any other changes that may occur during the testing. After NDE is complete, the pipe sample will be dissected and microscopy will be performed to discern differences between the surfaces in the water/sand environment vs the top area of the pipe that is not exposed to water/sand erosion.

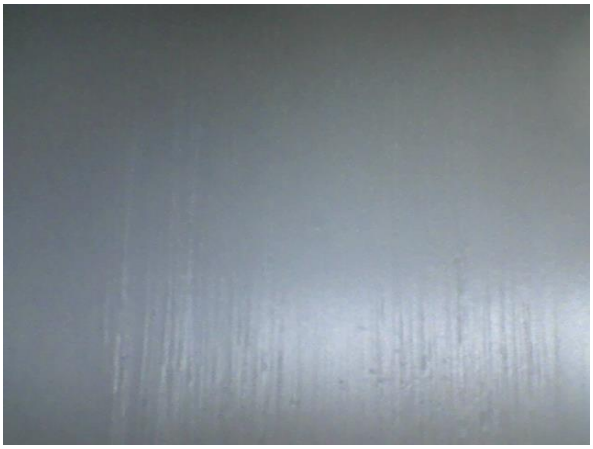


Representative image of scratch profile analysis to be done at the end of testing.

There are currently 5 pipe samples under test. Pipe sample 4-3 has now been under test for a period of 21 days. There is good indication in the mixing blade area that there is polishing and some erosion happening on the pipe wall. This is by visual and touch inspection only at this point, but there is a smoothing and apparent reduction in the severity of the scratches. To the touch, the abraded area of the pipe near the mixing blade is smoother than higher on the pipe wall away from the mixing blade.

Current Tests			
Pipe ID	Test Station	Conditions	Test age (12/22/22)
5-2-2	1	865 RPM, RT	17 Days
4-3	2	1300RPM, RT	21 days
16-1-2	3	865 RPM, RT	17 Days
16-3	4	865 RPM, 140°F	21 days
5-2-16	5	865 RPM, 140°F	17 Days


Initial image near mixing blade


21 Day image near mixing blade

The goal of this testing is to create a laboratory scale representative test to be able to quantify internal pipe erosion and erosion rate. This data will be able to be used to create a lifetime use prediction model for the NMP.

Task 10 – The 1st quarterly status report was provided on 1/4/22. The 2nd quarterly status report was provided on 3/31/2022.The 3rd quarterly status report was provided on 6/30/2022. The 4th quarterly status report was provided on 9/30/2022. The fourth quarterly collaborative meeting occurred on 9/21/2022. The Fifth quarterly meeting was hosted on 12/16/22 with its quarterly report submitted on 1/4/2022. TAP attended two meetings 7/13/2022 and 11/29/2022, TAP was invited to the quarterly meeting on 12/16/2022 and these meetings will be combined going forward.

The next quarterly meeting will occur in March 2023 pending Doodle poll feedback. It will be scheduled for a longer period of time ~2 hours, please see upcoming Doodle calendar poll.

While not tied to a specific milestone during the last quarter, the following activities were undertaken:

(1) EWI followed up with additional companies about joining the partnership. We have verbal confirmations and some project paperwork, but are waiting on final documents from each potential partner

5: Project Schedule –

Delays in procurement from Microwave Imaging and Air Coupled UT vendors have delayed completing the NDE procedural documents. Erosion testing will continue onward provided the test parameter adjustments. Schedule updates are highlighted in yellow below.

Task	Description	Quarter								
		1	2	3	4	5	6	7	8	9
1	Literature Review & Report	X	X							
2	Selection, Procurement & Preparation of Pipe Samples	X	X	X	X	X				
3	Draft NDE Procedures		X	X	X	X				
4	NDE Trials			X	X	X	X			
5	NDE Validation & Assessment					X	X	X		
6	Characterization of Erosion Properties and Detectability		X	X	X	X	X			
7	Development of NDE Procedures and Best Practice Guide						X	X		
8	Establish Field Inspection Requirements							X		
9	Virtual Workshop							X	X	
10	Progress Meetings (virtual and in-person)			X			X		X	
	Annual Review				X				X	
	Quarterly Progress Reports	X	X	X	X	X	X	X	X	
	Final Report								X	X
PM	Program Management	X	X	X	X	X	X	X	X	X

PHMSA and EWI have spoken about expanding the project to include additional samples from our added partners, these tasks and costs are being estimated, but will not be finalized until our new partners are formally added to the program and we understand pipe available to EWI for testing.