External Quarterly Report

Date of Report: 11th Quarterly Report – June 28, 2024
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
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For quarterly period ending: June 30, 2024

1: Items Completed During this Quarterly Period:
The Eleventh quarterly update meeting was held virtually on June 25, 2024.

Activity during Q11 was delayed in part due to (1) difficulties in working with the ACUT subcontracted vendor and (2) coordination of the pipe damage program with the full suite of expected pipe samples and the range of NDE methods – to include ACUT.

The final set of additional pipe samples were delivered to EWI in February 2024, so now all expected donated pipes are on-hand for NDE evaluation. These additional pipes provide two alternative pipe production methods and expand the type and size of pipes to be evaluated by NDE. In addition, due to the type of manufacturing and the materials used to produce these pipes, the program now has the opportunity to examine the viability for NDE inspection for a wide-ranging portfolio of non-metallic pipe (in terms of pipe materials, type of reinforcement, manufacturing methods, design service, and size of pipe). This expansion of the project pipe portfolio should also enhance the knowledge gained from the pipe damage task, which will evaluate the effectiveness of UT and thermography methods for detecting, characterizing, and sizing intentional damage to the inner and outer jackets and reinforcement layers.

The vendor that had been contracted to perform air coupled UT (ACUT) inspections, has not provided a report for the initial scans they performed in 2023. After several unsuccessful attempts to communicate and pursue completion of the contracted work, EWI decided in December 2023 to cancel the contract and assess other options. Two other North American ACUT vendors were approached, but one did not have the resource availability to complete the work within a reasonable timeline due to prior commitments, and the other was hesitant the undertake the work without extensive development effort up front. Therefore, EWI decided to acquire the necessary probes to enable the ACUT scans to be performed in house. The necessary hardware was ordered in January 2024. EWI received the hardware and performed functionality tests in May 2024. ACUT scans can now be completed with the existing planned project execution timeline and included in the pressure test and mechanical damage evaluations.

Item #	Task #	Activity/Deliverable	Title
21	10	Submit 11th Quarterly Report	10th Quarterly Status Report

2: Items Not Completed During this Quarterly Period:

Item #	Task #	Activity/Deliverable	Title
21	11	Summary Report	Inspection of Smart Pipe Samples
30	11	Air Coupled UT Microwave NDE report	Microwave NDE subcontractor added & EWI Air Coupled UT effort

Due to the delays in receiving additional pipe samples in Q9 and early Q10, the planned NDE trials under Task 4 and the follow-on Task 5 for NDE statistical analyses have not been completed. The expected pipe samples arrived by mid-February 2024, allowing initial inspections to establish baseline condition are underway.

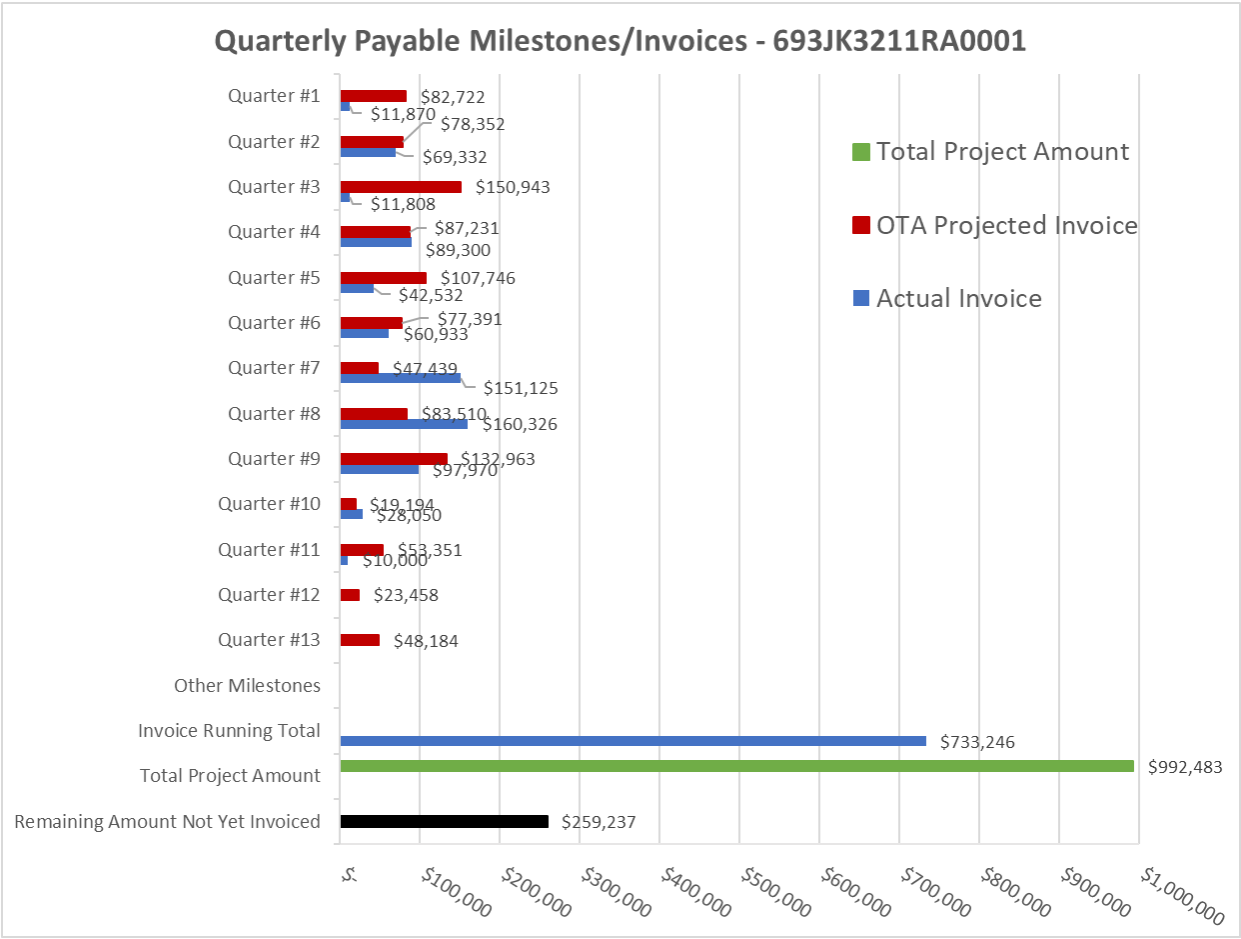
Completion of the intentional pipe damage matrix was planned for Q9 but has been put on hold to allow the expected new pipe samples to be part of this sample set. Pipe damage trials will begin July 2024. This will then allow completion of a comprehensive statistical assessment of NDE detection and characterization analyses under Task 5 covering manufacturing anomalies, minor in-service wear and tear and more substantial simulated field damage features. These inspections will include ACUT scans performed by EWI.

Q11 Task 29 inspection of Smart Pipe samples was delayed as EWI acquired the ACUT equipment and performed initial evaluation of this new equipment. Pressure testing of this pipe is expected to begin in July. Smart Pipe has expressed desire to observe these tests which will likely be scheduled in August 2024.

Note initial Air Coupled UT and Microwave reports have been provided, but additional reporting on new pipe as not, hence the incomplete status.

3: Project Financial Tracking During this Quarterly Period:

The actual spend is behind planned. This is due to a combination of pipe delays, contract modifications, and challenges faced with the most recent NDE at pressure scope of work. EWI has used three methods to hold pressure without success. Another approach will be made in July.


Quarterly Payable Milestones/Invoices - 693JK3211RA0001
Quarter #1
$82,722
$11,870
Quarter #2
$78,352
$69,332
Quarter #3
$150,943
$11,808
Quarter #4
$87,231
$89,300
Quarter #5
$107,746
$42,532
Quarter #6
$77,391
$60,933
Quarter #7
$47,439
$151,125
Quarter #8
$83,510
$160,326
Quarter #9
$132,963
$97,970
Quarter #10
$19,194
$28,050
Quarter #11
$53,351
$10,000
Quarter #12
$23,458
Quarter #13
$48,184
Other Milestones
Invoice Running Total
$733,246
Total Project Amount
$992,483
Remaining Amount Not Yet Invoiced
$259,237
Total Project Amount
OTA Projected Invoice
Actual Invoice
$-
$100,000
$200,000
$300,000
$400,000
$500,000
$600,000
$700,000
$800,000
$900,000
$1,000,000

4: Project Technical Status –

Item	Task	Activity/Deliverable	Title
1	**1**	Task report summarizing findings of literature review	Literature review of recent research on NDE of polymers & composites - issue task report
2	2	NMP sample matrix detailing type of pipe and defects, anomalies, or damage per sample	Prepare detailed matrix of NMP samples
3	10	Submit 1st quarterly report	1st Quarterly Status Report & Quarterly collaboration meeting
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
11	6	Perform inner linear erosion tests & assess NDE detection	Task report summarizing erosion test procedure and results, and NDE inspection results
12	10	5th Quarterly Status Report	5th Quarterly Status Report & Quarterly collaboration meeting
13	4	Comprehensive NDE trials on NMP samples and provide report summarizing procedures and initial outcomes	Task report summarizing NDE methods, procedures and initial outcomes.
14	4	Task 4 NDE Project Review	Review Progress to review NDE inspection data, outcome, and Trends – completed June 2023, reuploaded 2024
15	10	6th Quarterly Status Report	6th Quarterly Status Report & Quarterly collaboration meeting
16	5	Complete NDE validation and assessment. Provide task report document NDE results - POD and sizing performance.	Task report summarizing NDE outcomes and discussing viability of various NDE methods.
17	10	Submit 7th Quarterly Report	7th Quarterly Status Report & Quarterly collaboration meeting
18	12	NDE Report Update	Additional NDE effort predamage
19	12	Mechanical Damage Summary	Mechanical Damage Added scope
21	10	Submit 8th Quarterly Report	8th Quarterly Status Report & Quarterly collaboration meeting
22	13	Corrosion Damage summary Table	Corrosion Damage Added Scope

24	**10**	Submit 9th Quarterly Report	9th Quarterly Status Report & Quarterly collaboration meeting
27	**10**	Submit 10th Quarterly Report	10th Quarterly Status Report & Quarterly collaboration meeting
27	**10**	Submit 11th Quarterly Report	10th Quarterly Status Report & Quarterly collaboration meeting

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 from two new project team members in December and in mid-February. The Pipe Matrix spreadsheet was updated 3/6/2024.
Task 3 – A revised internal NDE procedures report was prepared in February 2024 to update the original procedures with advancements that have been identified during this program. A revised compendium of NDE procedures was issued February 2024.
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.

Initial air coupled UT (ACUT) scans were completed by Airstar in March-April 2023. Methods for ACUT sensor calibration, determination of sensor offset distances and scanning direction have been identified. Early observations suggest good sensitivity for detecting minor manufacturing anomalies and for dealing with typical pipe eccentricity and dimensional variances (wall thickness variability, air gaps in unbonded pipes, etc.). Unfortunately, data analysis and reporting by Airstar has not been completed and attempts to maintain communication with them have failed. EWI has subsequrntly decided to remove Airstar as a project subcontractor and has procured the necessary equipment to complete the ACUT scans internally. EWI procured an additional air coupled probe from Microacoustics to work in a pitch catch mode with the existing air coupled probe at EWI. Initial inspection from the outer surface indicates sound is only interacting with the first layer and not penetrating through all layers of unbonded pipe.

All NDE work at EWI has been done without internal pressure. This can reduce sensitivity due to natural air gaps that can occur between the inner liner, reinforcement, and outer jacket in unbonded pipe when unpressurized. An apparatus has been assembled to hold end plates in place on pipe segments and fill the pipe segments with water. A target pressure of 500 psi will be applied with the expectation that the pipe layers will be in better contact with one another and transmit sound waves. Once internal pressure can be applied, UT scans will be performed on selected pipes to assess improvements in feature detection capability for unbonded pipe. These UT scans will be performed with single element contact transducers and phased array transducers if the pipe wall is smooth enough to make intimate contact with the probe face. Air coupled UT will also be tested while the pipes are under pressure with the pair of probes focused on the outside surface for a pitch/catch arrangement.

Refinements in the thermography method have been made by implementing larger and higher wattage light sources, evaluating frequency of image scans, and assessing through-wall sensitivity using tapes, foils and small artifacts (zip ties, etc.) on the ID surface. Overall, sensitivity is improving and ability to

sense through-wall from the OD has been demonstrated. Features of the reinforcement layer are now detectable in several test pipes. The enhanced thermography procedures have been evaluated on the new pipe received by EWI from the two additional pipe manufacturers that have joined the program over the past 8 to 10 months. Initial inspection indicates poor resolution through all of the layers of these wrapped pipe styles.

EWI's initial plan for inducing mechanical and corrosion damage in selected pipe samples has begun now that the change request/project extension has been approved (June 5, 2023). The pipe damage test plan will be carried out in July-August 2024 with several NDE inspections to be completed for pre- and post-damage conditions.

A final NDE report will be provided following completion of the pipe damage task in Q12. This report will include documentation about the various NDE methods used in this program, present final results and observations, and discuss factors that either aid or inhibit feature or flaw detection, sizing and characterization for the types of NMP included in this program.

In Quarter 8 EWI completed microwave NDE testing with Evisive LLC using 24GHz probes. Non-metallic pipes were fully volumetrically inspectable using Microwave NDE. Four pipes were scanned from the outside while mounted on a rotating lathe-type unit with probes mounted to a linear stage for testing. This inspection will be repeated on pipe segments that undergo damage testing at EWI.

Task 6 – The entire erosion task has been completed. The cost share portion of this task was completed 5/31/ 2022 (Item #6 Task 6): erosion test cells have been built and a test method developed. The task began in December 2021 and was completed in June 2022. The federally funded portion of this work began in August 2022. Erosion testing and analysis on a total of nine pipes from three manufacturers has been completed and NDE inspections were completed in September 2023 which completes the federally funded portion of this task. To provide a realistic configuration where the flow path of the sand is in the same direction as pipe scratches and defects, EWI completed a test where a pipe was abraded internally circumferentially in line with the flow path of the sand. Post test analysis of the change in surface scratches was performed to approximate the amount of erosion that was induced by the impeller and sand throughout the test.

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.

A final task report was issued in October 2023.

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 6th quarterly meeting occurred 3/30/2023. The 7th quarterly report was completed on 6/29/2023. The 8th quarterly meeting is scheduled for 10/6/2023. The most recent quarterly report on 9/30/2023 was the 8th quarterly report. The quarterly meeting planned for December 2023 we eliminated based on feedback from PHMAS and the delayed pipe samples to conserve funds for 2024. EWI resumed meetings in 2024 on Wednesday March 24th and completed our 11th quarter meeting on June 25th.

Task 13 – Non-destructive evaluation of corrosion of a steel reinforced non-metallic pipe was performed intermittently over a period of 41 days. Corrosion was targeted in two locations of the pipe: a small hole on the outer jacket and a small hole on the inner jacket exposing the steel wire. Prior to corrosion, a full 360-degree inspection was performed on the outside of the pipe and a 120-degree inspection was performed on the inside of the pipe. At the end of the corrosion study with ultrasonic inspection an infrared video was recorded for 40 seconds or more to capture the heat transfer through the pipe and the steel wires.

Results were presented at the October 5, 2023, quarterly review meeting. During this meeting. a preliminary plan was proposed by EWI to expand on this effort to more fully quantify NDE detection thresholds for locating embedded corrosion damage, but project team members felt this was not needed at this stage. Future trials may be warranted but team members suggested the project focus remain as is to assess manufacturing anomalies and mechanically induced service damage.

5: Project Schedule – The project schedule has been updated to incorporate the modification requested in March 2023 and awarded in June 2023 as well as the project modification in March 2024.

Below is the Updated Project Schedule:

Task	Description	Quarter												
		1	2	3	4	5	6	7	8	9	10	11	12	13
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	X	X					
7	Development of NDE Procedures and Best Practice Guide										X		X	
8	Establish Field Inspection Requirements												X	
9	Virtual Workshop													X
10	Progress Meetings (virtual and in-person)			X			X		X					
	Annual Review													
	Quarterly Progress Reports	X	X	X	X	X	X	X	X	X	X	X	X	X
	Final Report													X
11	NDE Subcontractors											X	X	
12	NDE and Mechanical Damage								X					
13	NDE and Corrosion Damage									X				
PM	Program Management	X	X	X	X	X	X	X	X	X	X	X	X	X