

Internal Quarterly Report

Date of Report: 9th Quarterly Report – December 22, 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, 2023

1: Items Completed During this Quarterly Period:

The ninth quarterly update meeting was tentatively scheduled for December 13, 2023, but has been postponed after conversations with PHMSA DOT due to material availability causing delays. This is due in part to some delays in some Q9 objectives along with the recent receipt of additional pipe samples, which will allow initial work on these samples to progress for a more meaningful review over the next quarter. Work items completed this quarter include: (1) Final task report issued for the erosion testing effort, completing deliverable requirements for Task 6, (2) completion of arrangements for receipt of pipe samples received in Dec 2023, supporting Task 4, (3) initial planning for intentional damage to existing pipe samples to develop a targeted sample set containing representative field damage features for NDE trials (part of the expanded work scope approved June 2023), and (4) planning for alternative options to complete the air coupled UT (ACUT) trials on Task 4. The initial ACUT sub-contractor has been unable to complete required tasks so other options for completing these NDE trials are in-process to support completion of Task 4.

Item #	Task #	Activity/Deliverable	Title	Federal Cost	Cost Share
24 (previously 30)	10	Submit 9 th Quarterly Report	9 th Quarterly Status Report & Quarterly collaboration meeting	\$50,232	\$0.00
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	\$47,738.10	\$16,707

2: Items Not Completed During this Quarterly Period:

EWI anticipated receiving pipe samples from 2 new project team members that joined the project over the past 8 months. Receipt of these in-kind samples was expected no later than summer 2023. For various reasons, receipt of those samples has been delayed, which has interrupted the planned NDE trials under Task 4 and the follow-on Task 5 for NDE statistical analyses. Receipt of samples from one team member did occur in early December, which will allow a re-initiation of NDE trials beginning in January. 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 be completed in quarter 10 (January-March 2024), which will permit more comprehensive “field damage” NDE trials to be completed and reported Spring 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. Task 4 activities that have been delayed include:

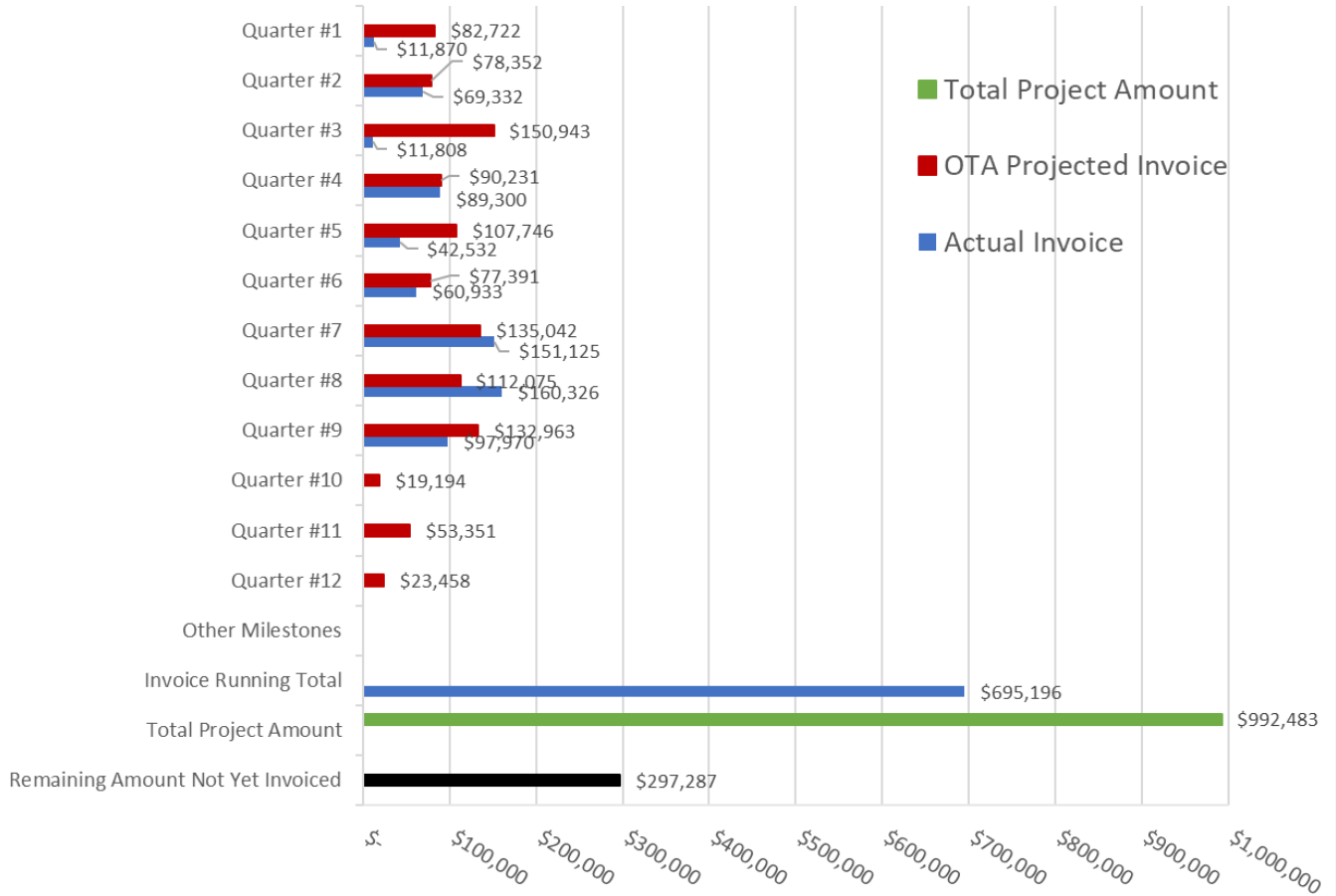
Item #	Task #	Activity/Deliverable	Title
14	4	Task 4 NDE Project Review	Review Progress to review NDE inspection data, outcome, and Trends
13	4	Task report summarizing NDE methods, procedures, and initial outcomes.	Comprehensive NDE trials on NMP samples and provide report summarizing procedures and initial outcomes

3: Project Financial Tracking During this Quarterly Period:

The actual spend is behind planned.

- EWI received a modification in June 2023 and anticipated receiving additional pipe materials as well. EWI is awaiting those materials as of September 30, 2023. Current updates expect the pipes to arrive late October 2023. EWI anticipates beginning change request CT scans and NDE work on these pipes. This material delay has caused a time delay, but EWI also has tried to use the opportunity to complete other tasks and allow for more efficient operating practices moving forward.
- Please note a correction was made to the table in Quarterly Report 8 based on the corrosion data table.

Quarterly Payable Milestones/Invoices - 693JK3211RA0001



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 2 nd Quarterly Report	2 nd 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 3 rd quarterly report	3 rd Quarterly Status Report & Quarterly collaboration meeting
9	10	4 th Quarterly Status Report	4 th 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
16	10	5 th Quarterly Status Report	5 th Quarterly Status Report & Quarterly collaboration meeting
26	10	Annual Review	Review Meeting (virtual)
15	10	6 th Quarterly Status Report	6 th Quarterly Status Report & Quarterly collaboration meeting
21	10	Submit 7 th Quarterly Report	7 th Quarterly Status Report & Quarterly collaboration meeting
27	10	Submit 8 th Quarterly Report	8 th Quarterly Status Report & Quarterly collaboration meeting
28	13	Corrosion Damage summary Table	Corrosion Damage Added Scope
30	10	Submit 9 th Quarterly Report	9 th 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 in late June and is updated the Matrix 10/31/2022.

Task 3 – The internal NDE procedures have been developed. NDE procedures for external technologies have begun, Airstar provided their report on 6/27/2023.

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 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.). Data analysis and reporting is in-process, but final reporting is delayed. EWI is reaching out to the vendor to assess the reporting schedule to allow completion of this task. Pipe samples were sent for initial microwave scans in mid-June. Those scans and a report were provided to EWI in July. Due to extensive delays by in completing task objectives, EWI has decided to pursue other options for completing ACUT trials. Two additional inspection vendors have been engaged to assess their capabilities to provide the necessary inspections and associated technical input in addition to a shift to internal testing with added equipment.

EWI has been in discussion for coordinating EWI UT inspections on samples to be tested by GTI or CFER. These UT trials would be particularly valuable since the samples will be pressurized while being subjected to denting loads. 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. Discussions are on-going to coordinate timing and schedules for these trials.

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 will be used on the new pipe samples to be received by EWI from the two additional pipe manufacturers that have joined the program over the past 8 to 10 months.

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). It is hoped that pipe samples to be supplied by partners can be used for the intentional damage trials as well since they have a different reinforcement and manufacturing methodology than the other pipe samples. Completion of the damage trials has been pushed back in an effort to include these pipes in this task. Since one set of new samples has just recently arrived, plans to complete the damage trials will begin in January 2024.

In Quarter 8 EWI completed microwave NDE testing 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. Full inspection results will be presented in an NDE report/presentation. EWI is currently reviewing the microwave scan data in details and plans to present details at the next quarterly review meeting.

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 and re-uploaded in January 2024 to the PHMSA Contractor Page.

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 8th quarterly report on 9/30/2023.

The quarterly meeting planned for December 2023 has been postponed at the suggestion of PHMSA. A postponement allows for additional delayed work to be completed in the January-February timeframe and will provide for a more useful and comprehensive review in early 2024.

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. The proposed schedule assumed EWI would receive pipe by June 1, 2023. With delays for receipt of the additional samples as discussed above, the schedule below has been adjusted to reflect expected timing of the remaining scope of work.

Task	Description	Quarter											
		1	2	3	4	5	6	7	8	9	10	11	12
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		X	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	X			
7	Development of NDE Procedures and Best Practice Guide									X	X	X	
8	Establish Field Inspection Requirements									X		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	X	X		
	Final Report									X	X		
11	NDE Subcontractors and GTI travel							X				X	
12	NDE and Mechanical Damage								X			X	X
13	NDE and Corrosion Damage									X			X
PM	Program Management	X	X	X	X	X	X	X	X	X	X	X	X

The schedule will be finalized when the last new partner's pipe samples are made available to EWI for testing. No firm data has yet been made for receipt of these samples.