Internal Quarterly Report

Date of Report: *5th Quarterly Report-December 31st, 2025*
Contract Number: *693JK32410015POTA*
Prepared for: *DOT-PHMSA*
Project Title: *In-situ Rapid-Cured-in-Place Pipelining System for Rehabilitation of Metallic Gas Pipe*
Prepared by: *RapiCure Solutions*
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For quarterly period ending: *December 31st, 2025*

1: Items Completed During this Quarterly Period:

Item #	***Task #***	***Activity/Deliverable***	***Title***		
1	*3*	*Develop Coating. Part 4*	*Develop Coating Part 2 – 4' Liners*	[redacted]	[redacted]
2	*7*	*Deliverable resin coating via pig applicator. Part 1*	*Pig Application*	[redacted]	[redacted]
3	*7*	*Deliverable resin coating via pig applicator. Testing Part 1*	*Deliverable … pig applicator Testing Part 1*	[redacted]	[redacted]
4	*3*	*Engineering Design Part 2*	*Engineering Design Part 2*	[redacted]	[redacted]
5	*12*	*Engineering Design Part 3*	*Engineering Design Part 3*	[redacted]	[redacted]
6	*13*	*Team Meetings*	*Team Meetings*	[redacted]	[redacted]
7	*10*	*Suggest Improvements*	*Suggest Improvements*	[redacted]	[redacted]
8	*14*	*5th Quarterly Status Report*	*5th Quarterly Status Report*	[redacted]	[redacted]

2: Items Not-Completed During this Quarterly Period:

Item #	***Task #***	***Activity/Deliverable***	***Title***		
1	***15***	***Paper Submission***		[redacted]	[redacted]

2	*3*	*Engineering Design Part 2*	*Engineering Design Part 2*	[redacted]	[redacted]
4	*3*	*Develop Coating Part 5*	*Develop Coating Part 2 – 6' liners*	[redacted]	[redacted]
5	*3*	*Develop Coating Part 6*	*Develop Coating Part 2 – optimized liner*	[redacted]	[redacted]
17	*9*	*Perform Tensile/4-point bend test*	*ASTM 2207-06 Preparations*	[redacted]	[redacted]

3: Project Financial Tracking During this Quarterly Period:

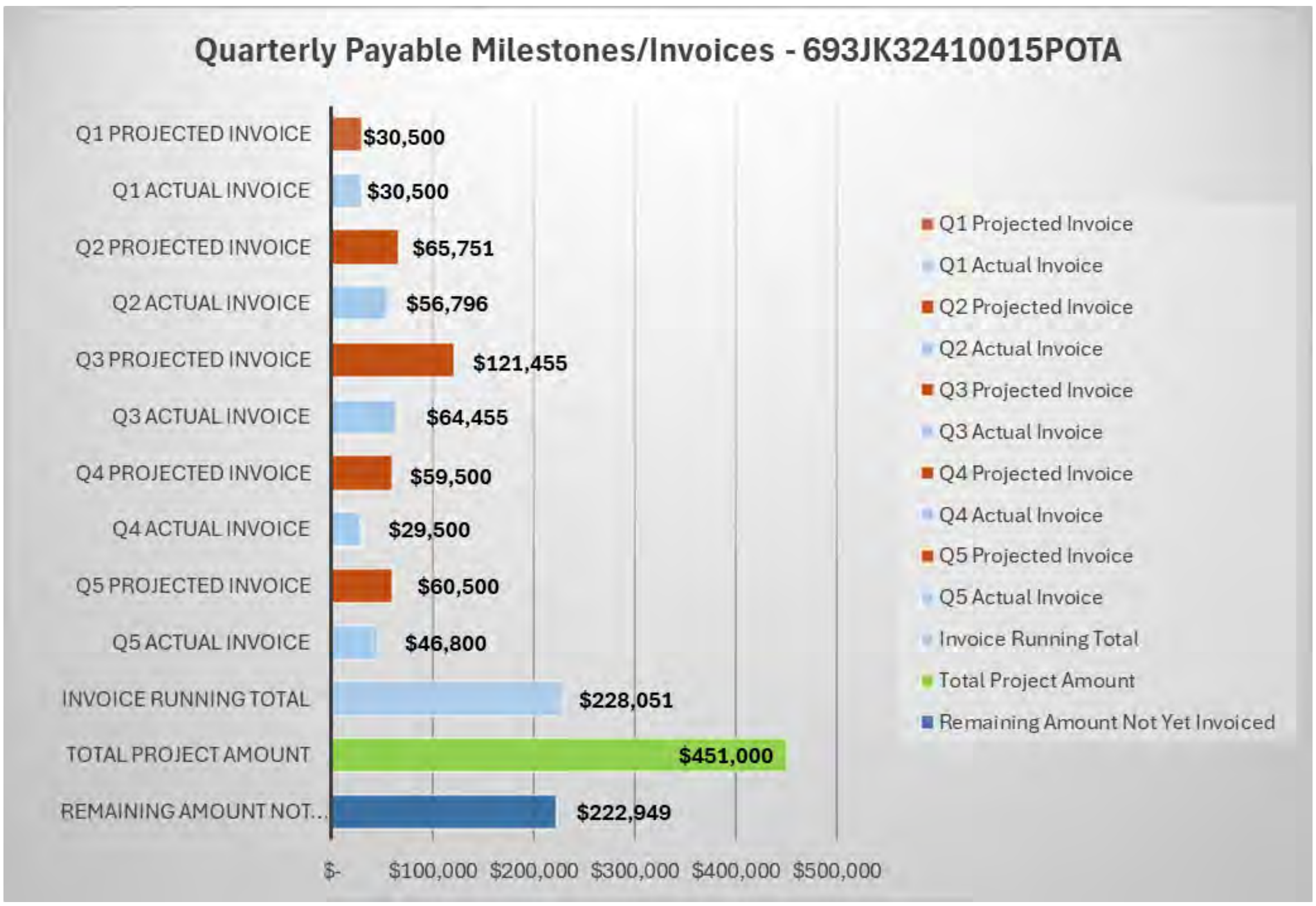

Figure 1. Budget plot.

4: Project Technical Status

Introduction/Background

The goal of this project is to develop a cost-effective commercial-ready near deployable product and solution for internal pipeline repair (cured in place pipe, CIPP) that enables service providers and pipeline operators to quickly protect their critical infrastructure immediately and for generations to come. During Quarters 1, 2, 3, and 4 the team successfully manufactured pipeline liners with varying lengths, from 16 inches to 4 feet in length with up to 1-inch thickness and 12-inch diameter that can be slipped into place and secured [redacted]. In addition, a sprayable coating was developed while addressing several key challenges and questions. Both processes required iterative tuning of the resin system and system optimization for RapiCure Solutions' frontally polymerizing resin products, cured only by heating at one end or spot of the coating. After quick initiation of the cure at one end or even one spot, a curing front traveled across the liquid (akin to a wildfire) at a controlled rate, and hardened in just minutes, compared to hours or even days for legacy rehabilitation of metallic gas pipes. Multiple ASTM tests were performed in Quarters 3 and 4 per ASTM F2207-06 and ASME PCC-2-2022 Article 403 recommendations. The results were analyzed and compared with the legacy resin solutions available in the market, Table 1. The resin formulation developed and tested for CIPP applications at RapiCure Solutions to rehabilitate gas pipelines is demonstrating optimal material performance, outperforming most systems on the market today across several categories. The coating was further developed for using pigs to apply the resin [redacted] During this quarter the project team continued to meet with relevant stakeholders, applied to speak or present these results at various relevant conferences in the US next year and is engaging potential customers with a possible first in-field deployment pending results of the next 2 quarters.

Table 1. Complete results of the ASTM tests performed for RapiCure Solutions' resin formulation and comparison to the literature where a required minimum/maximum value is reported and/or comparable legacy resin results are reported via technical datasheets.

ASTM	***RapiCure Solutions' resin***	***Remarks***
D790 Flexural Properties	[redacted]	>30 MPa is required in the industry for un-reinforced resin
D638 Tensile Properties	[redacted]	>20 MPa is required in the industry for un-reinforced resin

D2990 Creep Properties	>98% of initial strength is retained via extrapolated 50-year retention data for all temperatures tested: 25, 50 and 70 °C under 2, 3, and 4 N force for each temperature	≥50% of the initial flexural modulus expected to retain after extrapolated 50-year retention data
D696 Coefficient of Linear Thermal Expansion	[redacted]	<10E-05 /°C is needed for CIPP applications
D4060 Abrasion Resistance	[redacted]	≥100 mg loss is reported for legacy pipe coating resins
G14 Impact Resistance	[redacted]	>1.5 Joules is needed for *outside* pipe coating

[Item 1] [Task 3][Develop Coating. Part 4][Develop Coating Part 2 – 4' Liners]

RapiCure Solutions' resin formulation was successfully sprayed [redacted] on flat surfaces as well as inside of 12" internal diameter short pipes of up to 1 feet or so [redacted] After discussion with our TAP members including those from US-DOT the continued development of the spray coating was postponed until the necessary tool could be secured based on the initial project progress and learnings. After many iterative laboratory trials and discussions surrounding the optimal spray tool design [redacted] With the sprayer in hand, various trials were held providing valuable feedback on the spraying properties of the resin and outcome of the spray nozzle configuration [redacted], this sprayer system will need to be tested to determine the pot life within a line and impact to viscosity if the resin is traveling longer distances.

[redacted] The working time of the resin may increase with increased surface area to volume ratio. [redacted]

Figure 2. [redacted] internal pipe spraying tool [redacted] The premix resin is fed via blue hose attached to the joint.

The spraying trial was performed with the same resin formulation that was detailed in 2nd Quarterly Report. After preparing the resin components in the RapiCure Solutions laboratory, a simple power tool overhead mixer was used to prepare and mix the resin in a relevant outside environment. [redacted] The internal spraying tool was placed into the 12” internal diameter test transparent plastic pipe that was chosen for better inspection of the coating upon completion. [redacted] Then the resin was fed to the internal sprayer [redacted] this did not impede the ability to spray the pipe interior. The initial spraying quality was promising, with a nice surface finish, excellent resin build-up to reach a desired thickness, and no sagging of the resin. The sagging results are highly encouraging as the plastic pipe is a much more difficult surface to prevent sag than the metallic gas pipelines. Thus, we anticipate no challenges of the resin sagging when we trial in the upcoming quarters. Importantly, the coating was cured via frontal polymerization, curing started only by heating at one end of the coating. After quick initiation of the cure at one end [redacted] a curing front traveled across the pipe and hardened in just minutes. At this point, it was determined that there are three variables that need to be optimized to get the highest quality spray coating: (i) the resin feed [redacted] internal spraying tool, (ii) the rate of spraying head/nozzle rotation and (iii) the rate of pulling the internal spraying tool from the pipe. [redacted] Depending on the desired thickness of the resin, the rate of pulling the sprayer can be adjusted though no rate was calculated for the time being.

More trials are planned in the upcoming quarters [redacted] Overall, this trial further confirmed RapiCure Solutions' resin formulation is very well suitable for CIPP and specifically spray-in-place-pipe (SIPP) applications for internal pipeline repair that enables service providers and pipeline operators to quickly protect their critical infrastructure immediately and for generations to come.

Figure 3. The initial set-up after mixing [redacted] in the bucket. [redacted] placed in the 4' pipe with 12' internal diameter via the blue hose.

Figure 4. Top left: The spraying tool inside the 6' plastic pipe with 12" internal diameter pipe. Because of the leak at the joint, resin dripped to the bottom from the sprayer, this is NOT due to any sagging. Top right and bottom left: Despite some challenges in uniformity of the thickness applied with this sprayer, the coating fully frontally polymerized from one end to the other, and the coating will next [redacted] Bottom right: The obtained coating after the trial. The curing initiated from one end and self-sustains until the other end.

[Item 2] [Task 7][Deliverable resin coating via pig applicator. Part 1][Pig application] and

[Item 3] [Task 7][Deliverable resin coating via pig applicator. Testing Part 1][Deliverable resin coating via pig applicator. Testing Part 1]

The first trials of using a pig to spread the resin within a pipe were performed. Using a pig to apply resin to the inside of a pipeline would make the pipeline coating process cheaper and easier for many pipeline operators, who are already familiar with the use of pigs for pipeline cleaning. Towards this end, Part 1 of the pig applications were performed at RapiCure Solutions. [redacted] Figure 5. The transparent plastic pipe use enabled us to visually follow the frontal curing reaction inside of the pipe and perform better overall visual inspection. After a quick initiation of the cure at one end or even one spot, a curing front traveled across the liquid (akin to a wildfire) at a controlled rate and hardened in just minutes with a desirable smooth quality coating. The smooth internal surface of the plastic pipe is a more difficult surface to coat than the anticipated internal surface of a metallic gas pipe which would be rougher and a better surface energy match to the resin. The plastic pipe promotes non-stick and therefore has the highest potential for sagging of the resin. As such, a successful/promising trial(s) herein on the plastic pipe will suggest that better adhesion and coating will be achieved with carbon steel natural gas pipelines.

All pig pulling trials were performed in a similar manner, only differing [redacted] for each separate coating trial performed in a relevant outdoor environment. The [redacted] Figure 6. [redacted] After securing the pipe with one hand, the pig was pulled quickly (<2 seconds) via an attached copper wire and excess resin was caught into a painter tray. Following coating of the pipe, the curing was initiated from one end [redacted] and the curing front travelled to the other end for successful, complete coatings.

Figure 5. Transparent 3' PVC pipe [redacted]

[redacted]

Figure 6. The initial set up used for all pig-pulling. [redacted]

<u>*Trial #1*</u>

For the first trial, the same resin formulation was used as reported in Quarter 2. Although it was shown that this formulation can be sprayed [redacted] pig pulling herein proved challenging. After pulling, a thin coating was observed which quickly pooled at the bottom of the pipe, Figure 7. This observation suggests that the viscosity of the resin is may be too low for a pig application leading to uneven surface coating, although it is superior for spraying.

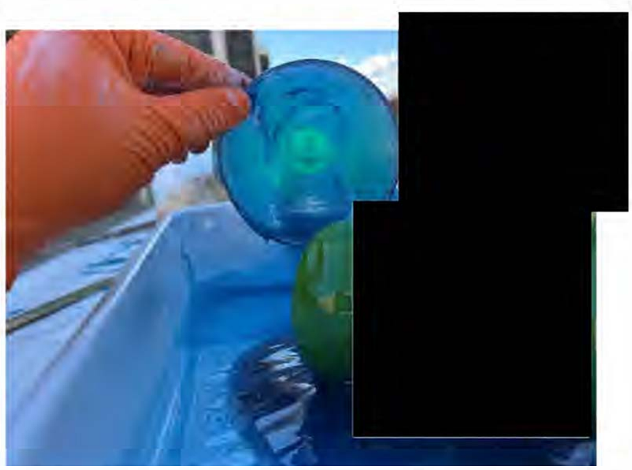

Figure 7. Although the premix resin yielded somewhat acceptable coating, it was observed that the resin pools at the bottom while sagging.

Trial #2

For the second trial, the resin formulation was slightly modified in such a way that more viscous resin was obtained just to see if increasing the viscosity would be beneficial. This made the resin more viscous and this resin system is colored slightly green. After the pull, less pooling was observed at the bottom of the pipe and the coating was better suited for pigging. [redacted] the team learned that increasing the viscosity of the resin system would prove critical for successful resin pigging, but the method for increasing would also be critical. [redacted]

[redacted]

Figure 8. The pig-pulling was successful and created a good coating in the pipe. [redacted]

Trial #3

For the third trial, the same resin formulation used in Trial #1 was utilized [redacted] After the pull, the resin coated the pipe nicely with minimal pooling attributed to the higher viscosity compared to Trial #1, Figure 9. It was anticipated that this formulation should yield better adhesion and minimal pooling and sagging when applied with pigs in carbon-steel natural gas pipes.

It was also pleasing to observe that when the cure front is initiated from one end, it travels to the other end while hardening, as expected. It takes about [redacted] Based on this timing it would take about [redacted] for one mile coating under these conditions when initiated only from one end, [redacted] Therefore, we may [redacted]

[redacted]. It is noteworthy here that the rate also depends on the thickness of the coating, diameter of the pipe and other parameters.

[redacted] 

Figure 9. High-quality coating via pig-pulling is shown on the left. After the initiation at the opposite end, the self-hardening curing front is seen and highlighted with an arrow at the interface on the right.

<u>Trial #4</u>

The resin system used in Trial #3 had to be [redacted] hile a gel may be good for pig trials or even for extrusion, [redacted] Thus, the same formulation used in Trial #3 was prepared and tuned slightly so that when mixed to the fullest extent, the desired viscosity was achieved. The formulation used in Trial #3 was mixed [redacted] and the resin [redacted] resulted in the ideal viscosity over various trials. [redacted] After the pull, the resin coated the pipe with minimal pooling as observed before with Trial #3, Figure 10. It is anticipated that this formulation will yield better adhesion and minimal pooling and sagging when applied with pigs in carbon-steel natural gas pipes. It was also pleasing to observe that when the hardening process is initiated from one end, it travels to the other end while hardening.

[redacted] 

Figure 10. The pig-pulling set up after pouring the premix resin in front of the pig and sealing the hole with a painter blue tape (left). The high-quality coating after multiple pulls (center) and sealed hole after the cure (right).

Overall Pig Application and Testing Summary

The above detailed trials at RapiCure Solutions' facilities showed increasing viscosity of the sprayable resin formulation [redacted] results in a promising solution for coating the inside of pipeline using pigs. Trial #1 used the resin formulation developed as-is, [redacted] and most of the resin pooled at the bottom of the pipe after the pig pull. [redacted] increasing the viscosity of the resin proved promising in Trial #2, so this was evaluated further. In Trial #3 the resin formulation used in Trial #1 [redacted] showing promise [redacted] Finally, Trial #4 displayed a promising coating coupled with a well-defined hardening of the resin after initiation and a constant viscosity achieved. [redacted]

Like:

Impact on viscosity:

[Item 3] [Task #3][Engineering Design Part 2][Engineering Design Part 2]

Many meetings were held [redacted] during this quarter. The priorities of the internal spraying prototype tool were the focus of discussions. That is, the required properties of the spraying tool were discussed, identified, and determined. [redacted]

Figure 11 [redacted]

First and foremost, a [redacted] applicator tool for the prototype is needed that mixes the resin components [redacted] It was shown that RapiCure Solutions' resin formulation is well suited with spraying as detailed in Q2 as well as above. [redacted]

[redacted] spraying is homogeneous circumferentially with the same thickness. There will also need to be a way to initiate the hardening process after application. [redacted] to the tool to verify the anomaly location and monitor the coating at the repair site within the pipe. [redacted]

[Item 4] [Task 12][Engineering Design Part 3][Engineering Design Part 3]

The design team [redacted] [redacted] information from the previous design phase to drive brainstorming and concept generation. During the brainstorming phase, it became apparent that the pumping mechanism [redacted]

[redacted]

[redacted] models of the assembly and several meetings and discussions followed. Several concepts were created following the brainstorming session, the following is a summary of one of the primary concepts. The focus is on creating a uniform mixture of material and [redacted]

[redacted]

[redacted]

Figure 12. Internal pipe repair device prototype [redacted]

The mixing [redacted]

[redacted]

[redacted]

Figure 13. Pumping [redacted]

[redacted]

[redacted]

Fig [redacted]
Blue: [redacted]

Models of the system were generated, and the team was able to gauge this design's adaptability to fit within different sized pipes. [redacted]

[redacted]

Figure 15. Pipe size comparison. The prototype is shown installed in pipes.

This is one of several concepts generated for this prototype device but is representative of the approach and provides the level of detail of these concepts. Along with the internal spraying trial results as detailed above to design the spraying head/nozzle, the team is moving forward to finalize the prototype design.

[redacted]

[redacted]

[redacted]

[redacted]

[Item 5] [Task 13][Team meetings][Team meetings]

Continued team meets were held this quarter with many TAP members, either virtual or in-person. These meetings led to additional improvements, design changes, and commercialization-related outcomes. Additional outreach was performed with potential customers and experienced operators. A visit to [redacted] gas consortium with overwhelming support for this technology from various gas companies. The company [redacted] efforts next quarter will target applications for innovation and attendance to related conferences. A white paper is in the works to discuss the results of this project along with general SIPP/CIPP technologies as a direct result of the research outcomes from this work. The internal team meetings (within RapiCure Solutions) were held once a week to discuss the progress of the project as well as obtain feedback from other RapiCure team members about the progress of the project. Dr. Ercan Bayram and Dr. Heather Rubin hold weekly one-on-one meetings to discuss the progress of the project as well as planning to move forward with the project based upon results. Several external team meetings were held with members of the team either virtually or in-person to inform them of project decisions and discuss industry feedback on the results and progress. [redacted] visited with RapiCure monthly and the team is in discussion [redacted] The team has reserved [redacted] Additional pipe repair testing is in discussion [redacted] and stakeholders in attendance.

[Item 6] [Task 10][Suggest Improvements][Suggest Improvements]

Several critical developments were achieved in this quarter. The group established the viscosity adjustment for the PIG application of the resin. As outlined above, minor formulation iterations were performed to make sure the resin had the right viscosity and properties so that multiple pig trials can be performed in-field in the upcoming quarter(s). These trials also ensured the mechanical and chemical properties are retained. Internal spraying trials reinforced the goal of this project: To develop a cost-effective commercial-ready near deployable product and solution for internal pipeline repair (cured in place pipe, CIPP) that enables service providers and pipeline operators to quickly protect their critical infrastructure immediately and for generations to come. Additionally, the first drawings of the prototype spraying [redacted] Taken together the team is well-positioned as a direct result of this work to develop a decision-making matrix, design, and application tool with a technoeconomic analysis for the generation of robust rapid in-situ pipelining.

[Item 7] [Task 14][5th Quarterly Report][5th Quarterly Report]

Careful discussion and considerations were made with discussions, milestone modifications, and reporting in Q5. All monthly reports were completed and emailed/updated. This 5th Quarterly Status report details the progress of the project and related tasks.

5: Project Schedule –

The project is on time regarding project activities and ahead of schedule in some areas. [redacted] These tests are partially completed and will continue into the coming quarter.