



Detection of Buried FRP Composite Pipes Using NDT Techniques



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1 Background and Objectives

Pipelines are crucial in transporting petroleum products and water to consumers. The pipeline infrastructure in the US is facing major challenges, especially, corrosion of steel pipes and excavation damage of onshore pipelines. This project aims to develop, investigate, and compare alternative strategies for creating easily locatable Carbon and Glass Fiber Reinforced Polymer (CFRP and GFRP) and PVC pipes that will help address the above problems. Investigation of pipe detectability is done using Ground Penetrating Radar (GPR) and Infrared Thermography (IRT).



GPR equipment setup



IRT equipment



Type T thermocouple

2 Project Approach/Scope

Major tasks to achieve the objective of the project are:

- ❖ Develop, investigate, and compare strategies for detecting CFRP, GFRP, and PVC pipes
- ❖ Use aluminum or carbon fabric overlay on PVC and GFRP pipes for easy detection
- ❖ Use carbon nanoparticle overlay for GFRP pipes to facilitate detection
- ❖ Investigate and compare the detectability of the above pipes (buried) using GPR
- ❖ Investigate possibility of detecting buried pipe transporting hot liquid using IRT

3 GPR Test Set Up

- ❖ A total of 33, 5' long pipe segments of different materials and different external surface finishes were buried in 3 trenches.
- ❖ A combination of 3", 6", and 12" diameter pipes were buried with 2', 3', and 4' depth of soil cover.



PVC pipe with CFRP rings and GFRP pipe with Alum. rings



Pipe samples being buried

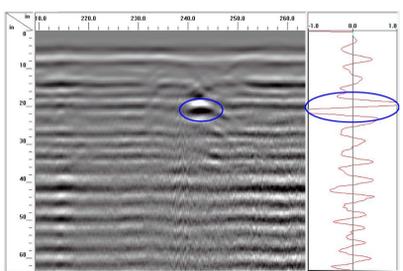


GFRP pipe with carbon nanoparticle coating

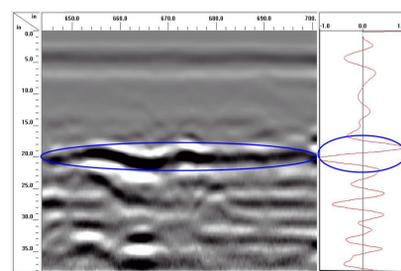
4 GPR Results

Results To-Date:

- ❖ Preliminary GPR data revealed many of the 3" diameter pipes buried at 2' depth.
- ❖ Site was relatively wet, with soil dielectric constant of 19.75 and 21.65 at 2' and 4' depth respectively.
- ❖ 400 MHz radar antenna produced significantly better result compared to 900 MHz radar antenna for buried pipe detection.



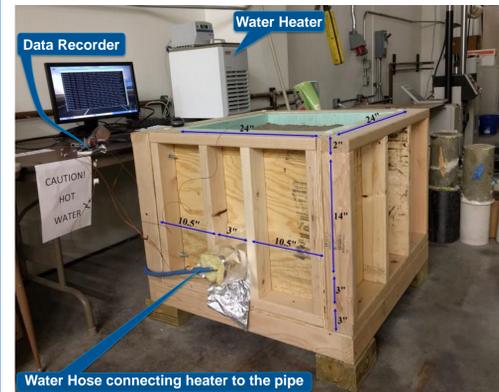
Sample cross-sectional GPR scan (left) and A-scan (right) over pipe wrapped with CFRP fabric



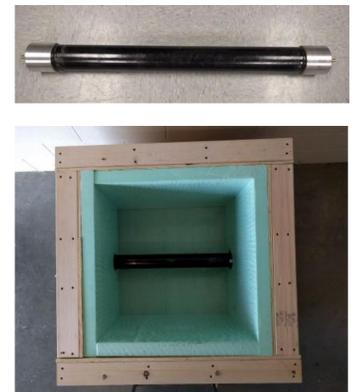
Sample longitudinal GPR scan (left) and A-scan (right) over pipes buried at 2' depth

5 IRT Test Set Up

- ❖ A capped 3" diameter CFRP pipe was buried in an insulated wooden box of internal dimension 24"x24"x22".
- ❖ Soil mixture of gravel, sand, and top soil in the ratio of 1:1:2 was used.
- ❖ Hot water at 95°C was pumped through the pipe, and temperature at pipe surface in the soil measured with thermocouples.
- ❖ Soil surface temperature measured with thermocouple and infrared camera.



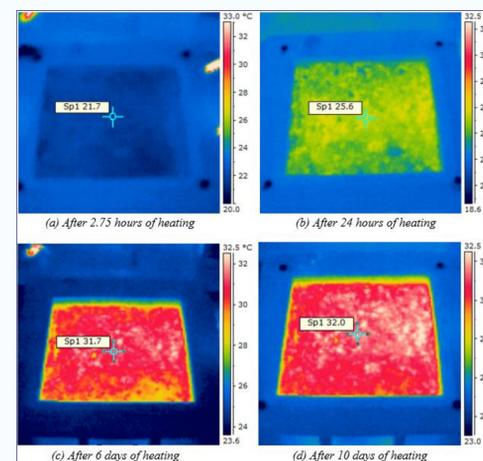
IRT test set up



Capped 3" CFRP pipe and interior of IRT box

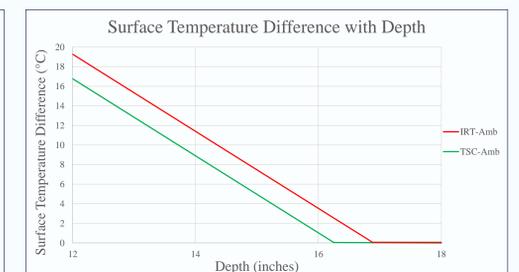
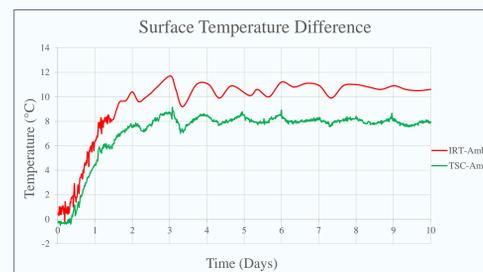
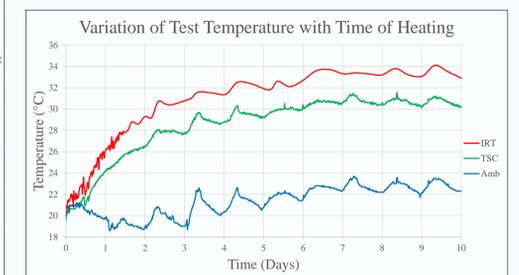
6 IRT Results

- ❖ Hot water was pumped through the buried pipe for 10 days.
- ❖ Temperature at soil surface increased gradually up to 6 days, after which it became almost constant.



Meaning of IRT data labels

- ❖ IRT – IRT temperature reading
- ❖ TSC – Thermocouple reading taken at the center of the soil surface
- ❖ Amb – Ambient/room temperature
- ❖ TSC-Amb – Difference between TSC and Amb
- ❖ IRT-Amb – Difference between IRT and Amb



IRT test results (top left – IRT images at different stages of testing, top right and bottom – IRT temperature variations)

7 Summary and Conclusions

- ❖ Result shows GFRP and PVC pipes with carbon fabric overlay is detectable using GPR.
- ❖ Buried pipe carrying hot liquid has a good potential of being detectable using IRT.
- ❖ Future tests on this project:
 - Further tests will be conducted using 200 MHz GPR antenna, which has deeper penetration depth and better for detecting deeper pipes.
 - Further GPR test will be conducted in different soil moisture conditions and results compared

8 Acknowledgments

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