CAAP Quarterly Report

Date of Report: 12/08/2020

Prepared for: *U.S. DOT Pipeline and Hazardous Materials Safety Administration*

Contract Number: 693JK32050006CAAP

Project Title: Nondestructive Diagnosis and Probabilistic Prognosis of Aging Plastic Pipe

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For quarterly period ending: 11/30/2020

Business and Activity Section

(a) Contract Activity

Nothing to report.

The industry partner will ship gas pipe samples in December.

(b) Status Update of Past Quarter Activities

One PhD graduate student (Bibo Zhong) has been assigned to develop the nonlinear ultrasonic test method for pipe degradation evaluation. The main activities in Q1 includes literature review and preliminary tests on PVC samples.
Another graduate student will be hired to perform plastic aging test (task 1) and material characterization (task 2). The student is expected to join in January 2021.

(c) Cost share activity

No charge to the project in this Quarter.

(d) Task 3: Develop Ultrasonic NDE technology

We performed theoretical analysis to derive the relationship between ultrasonic wave velocity and the nonlinear parameters of an isotropic material, for stress and temperature changing conditions. This theoretical work provides the foundation for experimental design and interpretation of test results.

1. Background and Objectives in the 1st Quarter

1.1 Background

Aging of plastic materials (PE, PVC etc.) often cause significant decrease of ductility, i.e. embrittlement. The objective of this research is to develop an ultrasonic NDT test method to evaluate the aging

deterioration of in-situ PE pipes.

1.2 Objectives in the 1st Quarter

To develop the theoretical relationship between ultrasonic wave velocity change and nonlinear parameter of materials. The hypothesis is that aged PE pipes will have different nonlinear behaviors due to embrittlement.

2. Experimental Program in the Nth Quarter

2.1 Experimental design

An experiment was performed on two PVC samples, one unaged, and one aged in high temperature. Ultrasonic wave velocity was monitored during thermal cycles.

3. Results and Discussions

The proposed ultrasonic test and analysis method was able to tell the difference in aged and unaged PVC samples. The aged PVC sample showed less sensitivity to temperature change.

4. Future work

In Q2, we will repeat the test on PE samples provided by the industry collaborator to validate the hypothesis. Then accelerated aging tests will be conducted to obtain samples aged to different degrees.

References

Sun, Hongbin, and Jinying Zhu. "Determination of Acoustic Nonlinearity Parameters Using Thermal Modulation of Ultrasonic Waves." *Applied Physics Letters* 116, no. 24 (2020): 241901.

Sun, Hongbin, and Jinying Zhu. "Nondestructive Evaluation of Steel-Concrete Composite Structure Using High-Frequency Ultrasonic Guided Wave." *Ultrasonics* 103 (2020): 106096.