High-Level Waste Pipeline Unplugging Technologies
Asynchronous Pulsing System

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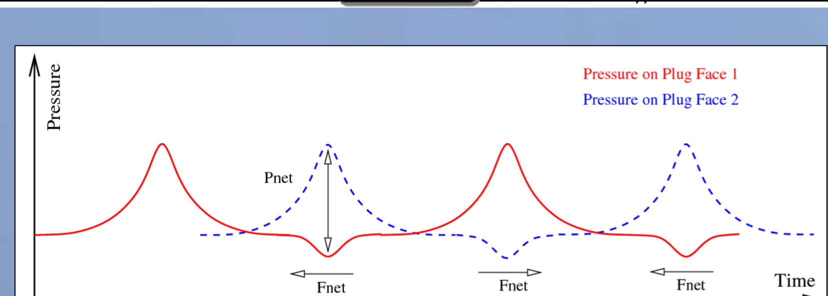
Background

- Transferring HLW between storage tanks or to treatment facilities is a common practice performed at the DoE sites.
- Changes in the chemical and/or physical properties of the HLW slurry during the transfer process may lead to the formation of blockages inside the pipelines resulting in schedule delays and increased costs.
- As such, the availability of a pipeline unplugging tool/technology is crucial to ensure smooth operation of the waste transfer.
- To improve DoE's capabilities in the event of a pipeline plugging incident, FIU has developed an unplugging technology called Asynchronous Pulsing System.

Introduction and Objective

Asynchronous pulsing method is based on the idea of creating pressure waves in a flooded pipeline from both ends of a blocked section. The waves are created asynchronously in order to break the mechanical bonds between the blockage and pipe wall. The vibration created by the asynchronous wave fronts result in a shear force applied to the blockage/pipe wall structure.

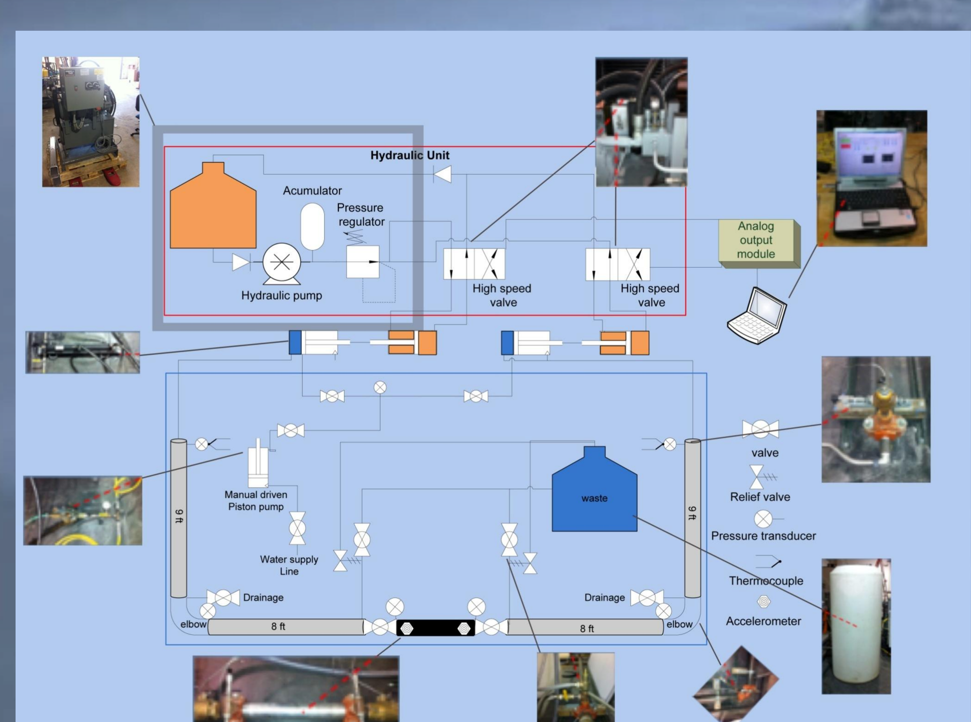
- Uses a hydraulic pulse generator to create pressure disturbances at two opposite inlet locations of the pipeline to dislodge blockages by pulsing the plug from both sides remotely.
- The heart of the asynchronous pulsing system are two hydraulic piston pumps that are powered by the pulse generation unit which is comprised of a hydraulic power unit and two electronically controlled high-speed valves.



Asynchronous Pressure Profile

Previous Work

- The test pipeline loop used to validate the method's unplugging capability contained two identical 18-foot 3-inch diameter schedule-10 carbon-steel pipeline sections with a plug between them to emulate a plug in the pipeline.
- The pipeline was instrumented with accelerometers, pressure transducers and thermocouples located at strategic locations to capture the changes of the induced disturbances inside the pipeline.



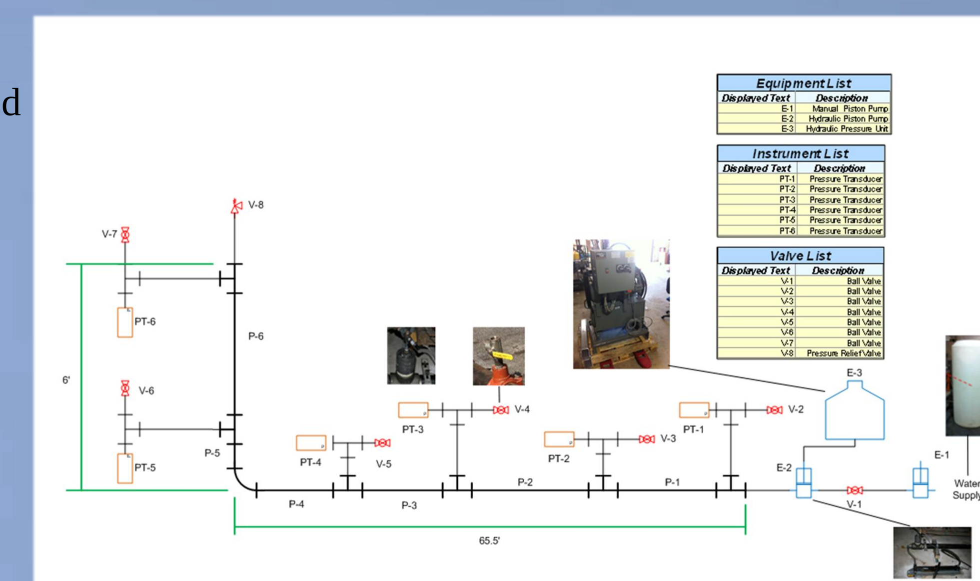
Unplugging Test bed

Tests and Results

After analyzing the data from the previous work, the following question needed to be answered:

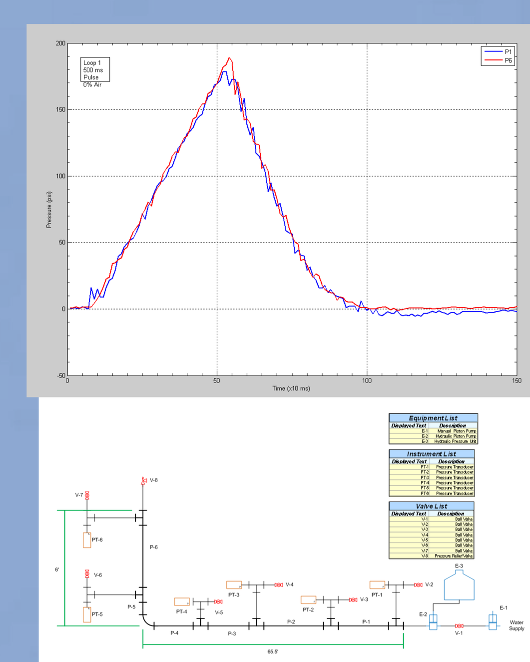
-How does the pipeline geometry and the quantity of air entrapped inside the pipeline affect the system's performance?

- We created loops up to 144 feet and used a different number of elbows. Tests were done on a single pipeline at a time with only one hydraulic piston pump and without a plug.

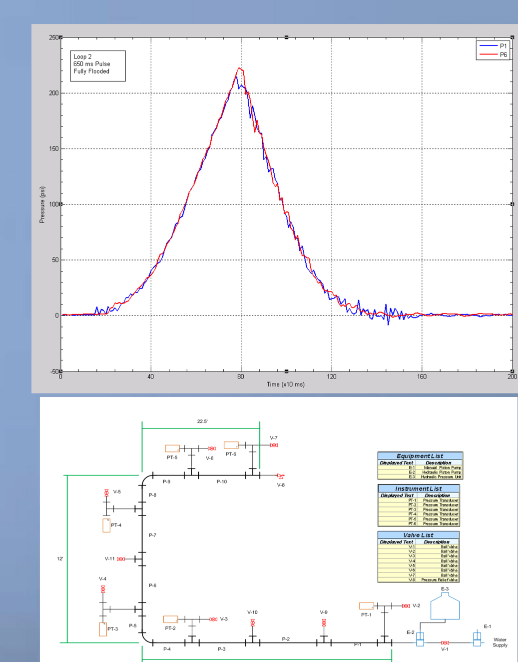


Loop 1 Test Bed
(Includes pictures of equipment used)

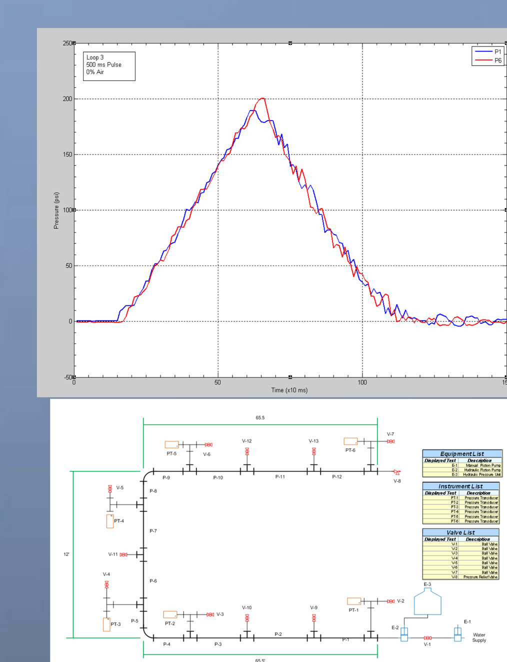
- The following graphs show the pressure wave at the end of the 3 different pipelines loops.
- It was observed that as the pipeline length increases, the time for the pulse to achieve its maximum amplitude also increases slightly. This relationship is important for the optimization of the system and the simulation program.
- There is a 10 psi pressure amplification between the inlet and the outlet pressure of the pipeline with an 8 millisecond pulse travel time. The pressure amplification at the outlet is a result of the kinetic energy created by the water column traveling in the pipeline.



Loop 1: 1 elbow and 72' length



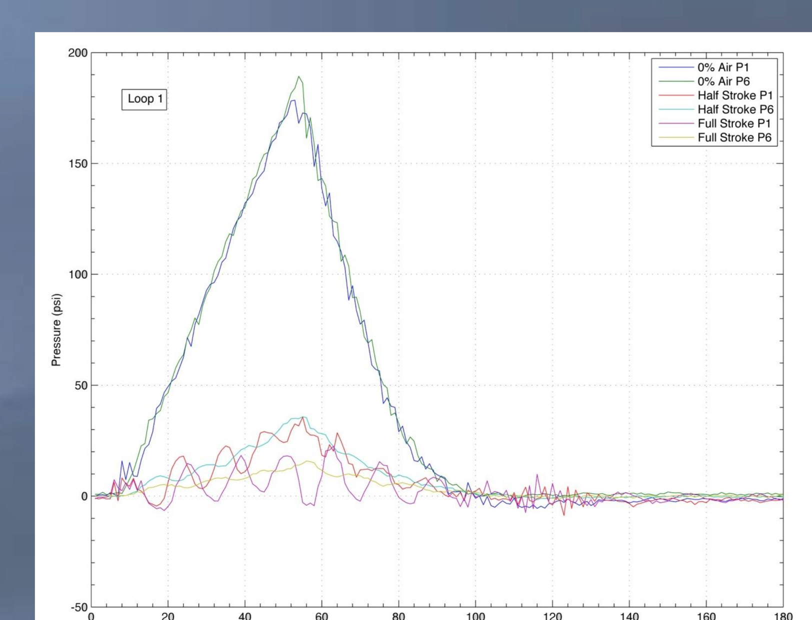
Loop 2: 2 elbow and 94' length



Loop 3: 2 elbow and 144' length

We also needed to understand in detail how the air affected the pressure pulse. Because of this, we performed pressure tests with 0 % air , 0.05 % (half pump piston stroke) air, and 0.1 % (full pump piston stroke) of air inside. The percentage is according to the total volume of the pipeline.

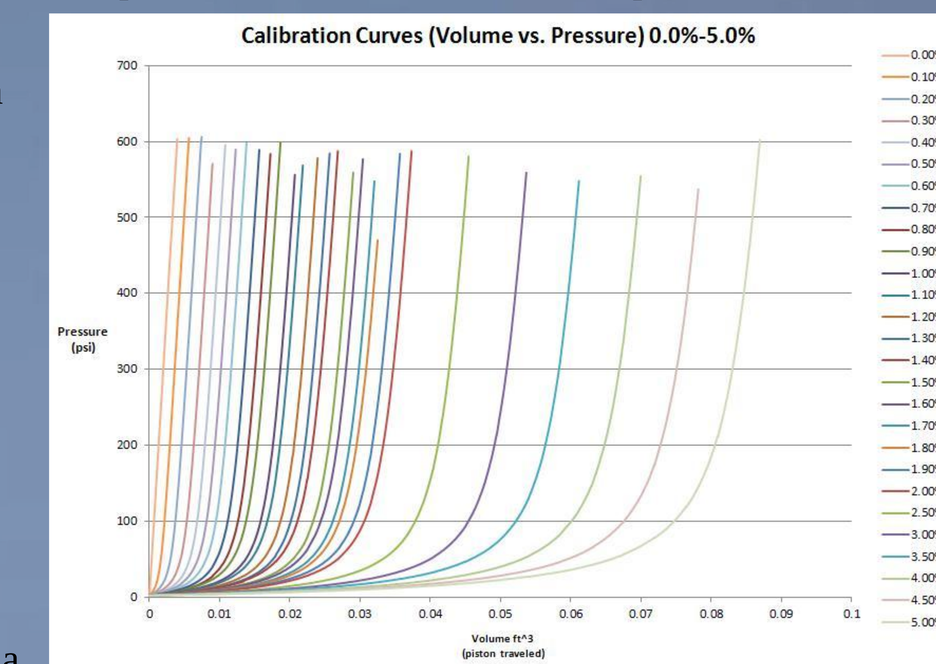
- After plotting the results, we observed that as little as 0.05% of air inside the pipeline would decrease the pressure significantly. As the graph shows, the 0% air at P6 (outlet) curve was very close to the to the P1 (inlet).
- On the other hand, the 0.05% curves at the outlet and inlet were very inconsistent and the peak pressure dropped significantly (from 190 psi to 35 psi).
- Moreover, the 0.1 % air was even worse compared to the 0.5% air (the peak is hardly noticeable).



Pressure vs. Time
(During the present of air inside the pipeline)

The following graph shows the relationship between pressure and the volumetric compression of air.

- When there is a 0% of air inside the pipeline, the graphs behave linearly. When the percentage of air inside the pipeline increases, the pressure increases exponentially at first. Once the air pocket is compressed, the pressure behaves linear and with the same slope as the line for the 0% air.



Pressure vs. Volume Piston Traveled
(0.0%-5.0% air inside pipeline)

Why does this occur?

- When the air is compressed, its density increases. When the density of air and water are the same, the system behaves as a combined body and there is no dampening. Therefore, energy is not lost.
- Using this data we are now developing an equation that represents the relationship shown in the graph.
- As a result, we will be able to predict how much the piston has to travel to compress the water and air inside into an incompressible fluid for any amount of air inside the pipeline.
- Due to safety regulations, there is a maximum pressure limit for the pipeline to be pre-pressurized at the Department of Energy sites. Unfortunately, this limits how much we can pre-pressurize the system to mitigate the effect of air inside the pipeline.

Because of this, we are evaluating the effectiveness of applying a vacuum to the system to reduce the amount of air inside the pipeline.

- We used a vacuum pump to reduce the pressure inside the pipeline to 25.5 Torr.
- After conducting several vacuum tests, an improvement in the system performance was observed. However, the vacuum did not eliminate all the air trapped inside the pipeline.
- We are currently working on adding a combination of vacuum and pre-pressurization capability to the system in order to obtain an incompressible fluid inside the pipeline.

Vacuum Pump System

Conclusion and Future Work

After performing tests, we concluded that although both the length and the air inside the pipeline affects the system, air affected it the most. Also, we concluded that some air could remain inside the pipeline if the pressure inside the pipeline is initially increased.

In future work, we would be determining and running tests using different types of vacuum systems that are capable of removing air from the pipeline. Also, we will develop longer pipeline test loops that simulates the pipelines at DoE sites. We will perform the tests we previously performed for percentages of air and this will enable us to find a relationship that depends on the size of the pipeline. This way we can use the same concept for any pipeline length.

Acknowledgements

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