Background Information: Hanford Site

- There are approximately 56 million gallons of high level waste (HLW) on the Hanford Site.
- There is to be a complete transfer of this HLW from single shell tanks to secure double shell tanks by 2040. This transfer is done via pipelines.
- Because of the variety of composition and characteristics in the waste some of the pipelines have formed blockages.
- Removal of waste in plugged pipelines is a challenge, the plug must be located and removed without damaging the pipelines.
- To continue the transfer of waste through the pipelines an unplugging tool/technology is needed to accurately locate the blockages and unplug the line.

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Design Metrics & Restrictions

Based on Hanford site pipelines and conditions, the crawler and its components must:

- Fit within 3 inch inner diameter pipes
- Be able to pull its own weight, and that of the tether
- Maneuver through a 90 degree elbows with 4.25 turning radii
- Be capable of removing plugs without damaging the pipelines
- Survive in a radioactive environment of 10 Gy/hr
- Have a maximum operating pressure below 300 psi
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System Description

- The peristaltic crawler is a pneumatic/hydraulic operated tool that propels itself by a sequence of pressurization/ depressurization of its inner cavities.
- It has three air cavities; front, and rear rims, and a double wall bellows assembly.
- The bodies inflate and deflate in sequence.
- The crawl moves in a worm like motion of the vessel by peristaltic movements.
- A spring system located at the back rim facilitates compression of the system as well as to prevent the hemo from over-extending.
- The peristaltic crawler includes a frontal attachment with a hydraulically powered unplugging tool and a camera for visual feedback of the pipelines condition.

Experimental Testing

Bench Scale Testing

- Demonstrated a navigational speed of 38 ft/hr
- Successfully performed unplugging operations on Bentonite, Kmag, and NaAlSi plugs
- Generated an axial Force of 108 lbs
- Test where also performed to determine the duration of the rims before they rupture and have to be replaced

The graph shows the results of the speed test conducted on a 3 foot straight section using multiple outer bellows configurations.

Pulling Force Test

Pulling force tests were conducted using the outer thinner wall bellows configuration. The maximum force recorded was 108 lb with a supplied air pressure of 50 psi. The graph shows the previous and latest results of the force test conducted.

Fatigue Testing

- It is estimated that total of 3,600 cycles will be required for the unit to navigate a 500 ft line.
- Different materials, configurations, and clamping pressures were tested to determine the best configuration for the rims (length between the back rims) for the best performance.
- The largest number of cycles recorded without failure was 1,260.
- An experimental fixture having the same outer diameter as the back rim was assembled and test were performed to determine the best configuration for the rims (length between the back rims) for the best performance.
- Increasing the distance between the clamp points increases the number of cycles until failure, however it makes it more difficult to navigate 90º turns. A distance of 1.23 inches was chosen.

Navigational Tests

Navigational tests were conducted using the engineer scale testbed. The performance of the system showed two major limitations due to effects resulting from using a longer pipeline:

1. Friction between the tether and the pipeline increases dramatically with distance.
2. Fatigue failure of the cavities, the rims rupture after a certain number of cycles.

Pulling Tests

- Friction between the tether and the pipeline created extreme pulling requirements over long distances.
- Elbows significantly increase pulling requirements.
- Flooding the pipe provided a drastic decrease in the required pulling force.

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