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Department Of Energy (DOE) Pipeline Unplugging Requirements Development

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ABSTRACT

Department of Energy (DOE) sites around the country have an ongoing effort to transport and process several tons of radioactive waste in the form of slurry (liquids and solids) from storage tanks to processing facilities. The system of pipes used for the transportation of this waste needs technology for maintenance and for the prevention (and correction) of pipeline plugging. The unplugging technologies that have been tested and evaluated at Florida International University include ones from NuVision Engineering, AIMM and AquaMiser. NuVision's technology acts as an ocean wave does on beach erosion. It can operate on a long pipeline that has drained down below a blockage. AIMM Technology's Hydrokinetic™ process uses a sonic resonance with a cleaning water stream. This sonic resonance travels through the water stream and transfers vibration to both the pipe and the blockage. The AquaMiser line of water blasting equipment combines 15,000- to 40,000-psi water injection technology to unplug pipelines. Some sites cannot allow this level of pressure in their pipes. After reviewing the results of every test, including the benefits, advantages and disadvantages of each technology, requirements were developed for pressure, personnel training, environmental concerns, safety, and compatibility with current systems, operability, reliability, maintainability and cost.

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1. INTRODUCTION

The use of nuclear power could be the number one solution to reduce the levels of greenhouse gases that warm the earth. However, the production of energy through the use of nuclear power has resulted in tons of spent nuclear fuel (SNF). In the U.S., more than 50,000 tons of commercial spent fuel is stored at 72 sites at or near nuclear power plants in 33 states of the US [1]. A system of underground pipelines is used for the transportation of SNF from storage tanks to processing facilities. There are several causes of plugging in this pipe system and because of the high levels of radioactivity, maintenance can be hazardous. The Department of Energy (DOE) Idaho National Laboratory (INL), in cooperation with Florida International University (FIU), is working on a project to identify the criteria needed to evaluate tank farm pipeline unplugging methods. FIU has tested several new unplugging methods, such as NuVision Engineering's Erosion Wave, the AIMM Acoustic Method, drain snakes and water blasters. DOE sites have also used high pressure, chemical dissolution and abandoning lines in place as means of dealing with plugged tank farm transfer lines. Unplugging issues may grow as decommissioning tanks and processing tank farm waste become more frequent. Several interested parties are looking at unplugging and plug prevention. Our effort has been to identify the barriers (in terms of meeting DOE site criteria and requirements) that unplugging methods will have to overcome to be implemented. Ultimately, the purpose is to identify the best, most effective and compatible method that can then proceed to field testing.

2. PROBLEM DESCRIPTIONS

2.1 Transportation of radioactive or nuclear spent waste (NSW)

DOE sites around the country have an ongoing effort to transport and process several tons of radioactive waste in the form of slurry (liquids and solids) from storage tanks to processing facilities. A system of underground pipes is used for this purpose. Due to high levels of radiation, the pipes are difficult to access for maintenance or monitoring. Plugging of the pipes creates a difficult and hazardous problem to correct.

Some of the causes of plugging were identified during this requirements development. Settling of solids occurs because the flow rate may be too low or the solids volume fraction may be too high. Operational upsets also cause interruption of the waste flow, inadvertent entrainment of solids in the feed, and changes in the environmental temperature. Chemical instability due to temperature changes can produce precipitation, gel formation, or other transformations that cause plugging.

The DOE sites, including Hanford, Savannah River (SRS), and Idaho, are actively engaged in the transfer of radioactive wastes. Most waste that is stored in underground storage tanks is transferred as slurry (liquids and solids) through conventional pumping and piping systems. Some of these piping systems cover distances ranging from less than one hundred feet up to several miles. The pipeline design varies at each site. Sharp (small radii) 90° elbows are typically found at the Hanford Site, whereas large 42-in radius of curvature sweeps are typical at Savannah River. Moreover, as waste is transferred from tanks, it is directed through a series of shorter pipes, valve pits, and jumpers, as is the case at Hanford. In all cases, the transfer lines are buried approximately six feet underground due to high levels of radiation. For this reason, there are very few or, in some cases, no access ports in the pipelines for maintenance or monitoring. Both single-wall pipelines and double-jacketed pipelines (i.e., a pipe within a pipe) are found at these sites. Most of these pipes have aged to varying degrees, depending upon the types of waste flowing through them. Old lines are difficult to maintain, and constructing new underground lines is cost-prohibitive [2].

2.2 Why do these pipelines plug?

Pipelines plug for a variety of reasons, including the following:

- settling of solids because the flow rate was too low or the solids volume fraction was too high;
- operational upsets – interruption of the waste flow, inadvertent entrainment of solids in the feed, and changes in the environmental temperature;
- chemical instability – precipitation, gel formation, or other transformations due to temperature changes, local concentration changes, or mixing and pumping of several wastes that are not in equilibrium;
- hydrodynamic instability – transition of the flow from one flow regime to another (turbulent to laminar) or from one flow pattern to another (homogeneous to heterogeneous) as a result of an external change or as a result of changes in slurry properties occurring during transit;

- piping components that are prone to solids deposition – sharp bends such as those found in Hanford PUREX connectors, unheated jumpers, flow restrictions, etc;
- deposition of solids; and
- crystal growth on surfaces.

Pictures such as the one shown in Figure 1 are not very common because of the dangers of radiation which make access to the pipelines difficult.

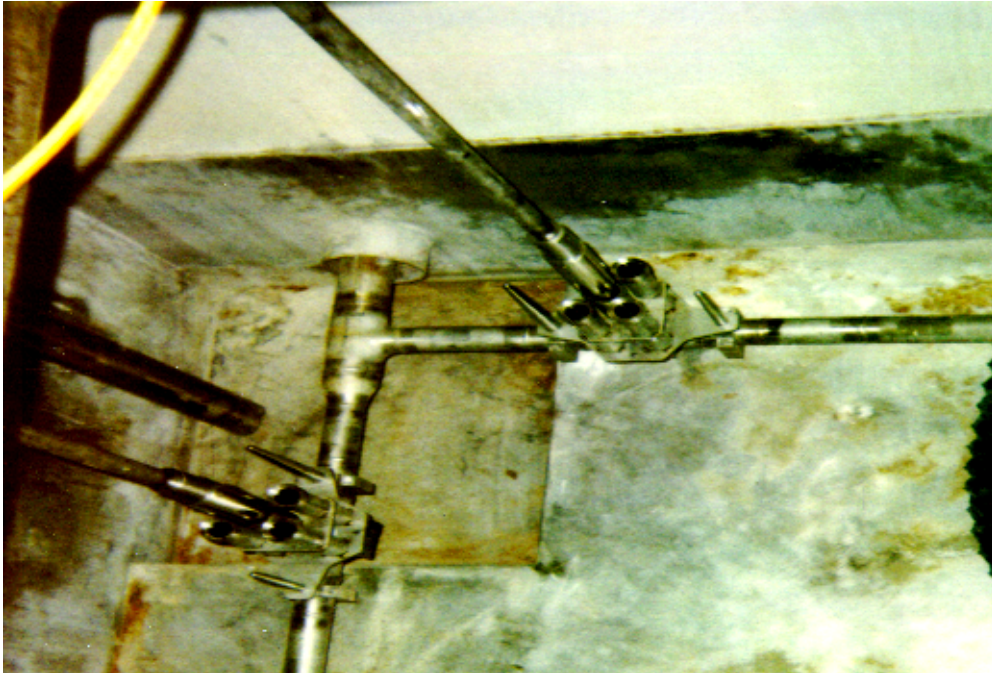


Figure 1. Tank farm plug occurred at the Idaho National Laboratory.

A tank farm plug occurred at the INL because a valve on a 3-inch pipe did not open fully (globe valve not ball valve). Solids clogged the restricted passage. The globe valve was removed and no plugging has occurred since that event. Figure 2 shows the INL tank farm.

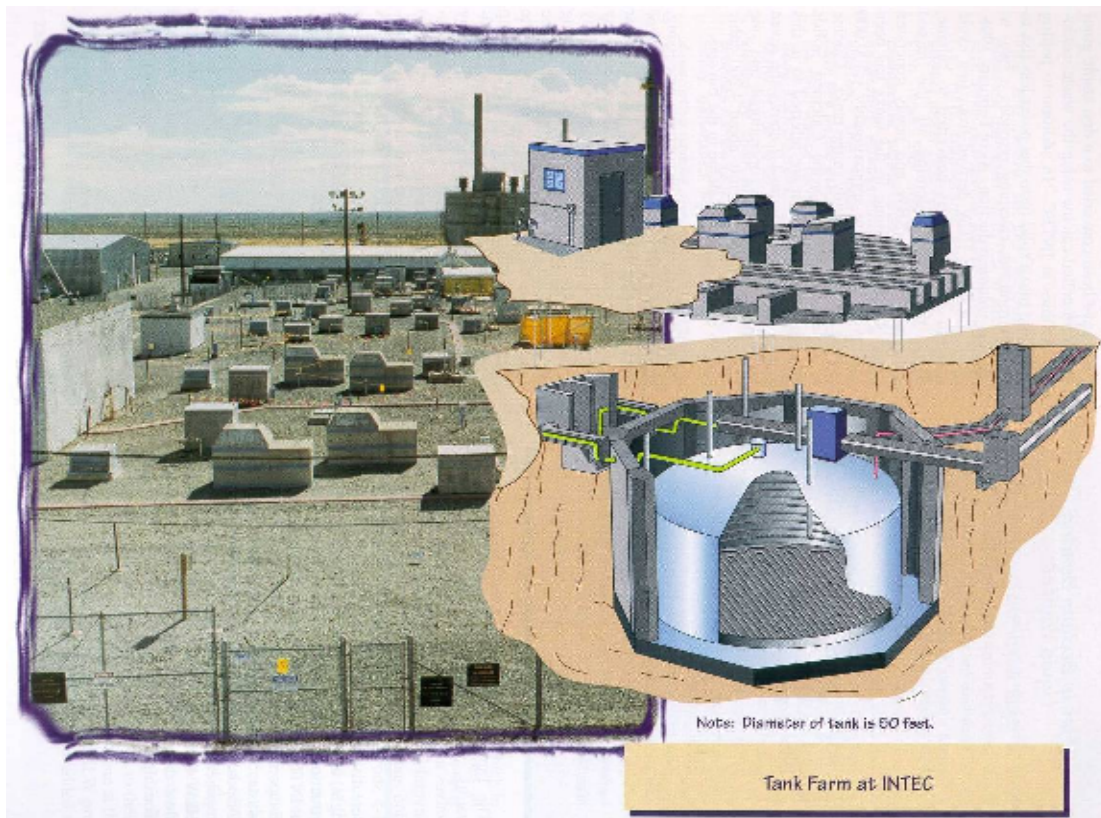


Figure 2. Tank farm to process Spent Nuclear Waste at INL.

3. AVAILABLE PIPELINE UNPLUGGING METHODS: BENEFITS AND LIMITATIONS

3.1 Unplugging methods

The unplugging methods varied by the technologies investigated:

NuVision method - NuVision's technology acts on a pipeline plug as an ocean wave acts on beach erosion. It can operate on a long pipeline that has drained down below a blockage.

AIMM Technology's Hydrokinetic™ Technology - The Hydrokinetic™ process uses a sonic resonance with a cleaning water stream. This sonic resonance travels through the water stream and transfers vibration to both the pipe and the blockage.

AquaMiser - The Aqua Miser line of water blasting equipment combines 15,000 to 40, 000 psi water injection technology to unplug pipelines.



Figure 3. Typical installation of Hydrokinetic™ System.

3.2 Benefits

NuVision's benefits:

1. Short mobilization and demobilization time possible with an adaptive jumper.
2. Can be used to deliver chemical solvent to the blockage where a solvent may be of assistance in loosening a blockage.
3. Can be applied to the section of the pipeline that has drained down below the elevation of the blockage.
4. System works under relatively low drive pressures (100 psi tested).
5. Technology can negotiate many elbows (unlike mechanical devices, this method is unaffected by elbows in the pipeline).
6. Technology can be operated remotely.
7. No water is discharged until the blockage is cleared, therefore minimizing the amount of liquid added.
8. Location of the blockage can be determined by the amount of water required to back-fill the pipeline.

AIMM's benefits:

1. Short mobilization and demobilization time.
2. Commercially available.
3. Water is discharged away from the operator.
4. Quick unplugging time.
5. Can negotiate many elbows before and after the blockage.
6. Easily reached and expelled the plug through the 1500-ft of pipeline available.
7. Technology can be operated remotely.
8. According to the vendor, the length of pipeline the system can reach is virtually unlimited. However, due to physical restrictions of our test site, this claim could not be verified.

Aqua Miser's benefits:

1. The Aqua Miser has the potential to be more effective on the Gravity Drain Line Test Bed than Roto-Rooter Plumbers and A-to-Z technology.
2. Low water usage.
3. Short mobilization and demobilization time.
4. Commercially available.

5. Relatively low cost.

The technology has the capacity to gain access through a 1-inch access port if deemed necessary on Test Bed #1.

3.3 Limitations

NuVision's limitations:

1. Length of reach in an empty pipeline is limited by the strength of the vacuum pump.
2. Positive and negative pressure cycles acting to loosen a blockage was effective for most blockage types; however, unplugging time is relatively high as compared to other methods when considered without the effect of vacuum and pressure cycles.

AIMM's limitations:

1. Water is not contained or recycled, although under actual conditions, the water would be discharged at the final destination of the pipeline (i.e., storage tank).
2. High water usage.
3. Technology was not able to gain access through the 1-in access port on Test Bed #1.

Aqua Miser's limitations:

1. Although technology is self-propelled, it is labor intensive.
2. Technology is unable to negotiate more than two elbows.
3. Technology is unable to flush out the blockages completely.
4. Water is not contained or recycled.
5. Water drains toward the operator.
6. Limited effectiveness on Test Bed #1 based upon the nozzle heads available during the demonstration.

3.4 Pressure requirements

NuVision's pressure requirements:

For the test bed conducted at FIU, NuVision was limited to 150 psi. This is because the clear section that was required for viewing the wave was made from PVC and was limited to 150 psi. The actual cross-site lines have a maximum pressure limit of 300-350 psi.

AIMM's pressure requirements:

During the demonstrations at FIU, the water pressures recorded at the manifold for filling the pipe ranged from 100 to 400 psi and the pressures for pulsating ranged up to 2400 psi. The air compressor had a pressure rating of 120 psi.

Aqua Miser's pressure requirements:

The Aqua Miser line of water blasting equipment combines 15,000 to 40,000 psi water injection technology to unplug pipelines [3].



Figure 4. NuVision Engineering pipeline unplugging skid tested at FIU.

4. WHAT METHODS HAVE BEEN USED AT DOE SITES?

The methods of pipeline unplugging that have previously been used at the DOE sites include the following:

- a) INL: Hydro pneumatic Rooter (hydrojet) and high pressure flushing.
- b) Hanford: Ultrasonic sensor used to measure the density liquid slurry during pipeline transport.
- c) SRS: Hydrojet (high pressure hose placed in pipe).

5. Conclusions

Westinghouse Savannah River Company (WSRC) has reviewed the list of potential evaluation criteria/requirements for tank farm pipeline unplugging and has the following comments and suggestions. A proposed weighting of the criteria is also provided.

5.1 General WSRC Structural Integrity Group Input to the Evaluation

The equipment needs to be safe to operate, it needs to be effective and it cannot damage currently installed equipment or the environment. In order to develop a mock-up, the pressure requirements, operability and compatibility with current systems need to be understood and evaluated. Once you have a mock-up that operates within the required pressures and will not damage currently installed equipment, it needs to be successfully tested. The weighting of requirements for selection of an unplugging method could be influenced by whether you want it to be retrievable or disposable. If the equipment needs to be retrievable, then the design needs to include reliability and maintainability aspects. The cost will be dependent on the choices made and the training of personnel will happen either way.

5.2 Other Important Points for SRS application

- The current design pressure requirement for a transfer line core pipe at SRS is 260 psi and the jacket is 150 psi. The currently installed transfer lines were designed to the old p-codes at a pressure of 150 psi.
- Current methods used to unplug transfer lines include 2 methods:
 1. Evaporator gravity drain lines (GDL) lines are unplugged by a vendor utilizing a high pressure lance (>2000 PSI),
 2. The Tank 50 - Z Inter area transfer lines and some other shorter sections of transfer lines (e.g., gravity drain lines from the evaporator systems) were installed with clean out ports (COP) that are basically pipes that allow

access to the core pipe for the purpose of "noodling" the line out if it were to become plugged. This is similar to snaking the line.

5.3 Criteria weighting

The criteria in Table 1 were ranked and weighted as high-to-low in importance to the Savannah River Site Liquid Waste Operations with input from the LW Structural Integrity engineering group.

Table 1. Pipe Unplugging Criteria

Evaluation criteria/requirements for tank farm pipeline unplugging:	Rank	Weight (out of 5)	Total (Rank*Weight)
Safety	11	5	55
Operability	8	5	40
Compatibility With Current Systems	10	4	40
Pressure requirements	9	4	36
Tested Effectiveness	7	4	28
Environmental	6	3	18
Reliability	5	3	15
Cost	2	5	10
Maintainability	3	3	9
Retrievability	4	1	4
Training of personnel	1	2	2

5.4 Pipeline Unplugging Evaluation Criteria

The following potential evaluation criteria/requirements for tank farm pipeline unplugging were developed by INL, in cooperation with FIU.

- Pressure requirements: The maximum pressure use at Hanford site is about 350 psi. The pressure used at INL is 200 psi. The Savannah River Site transfer line core maximum pressure is 260 psi.
- Training of personnel: Training should be easy.
- Tested effectiveness: Proven use in mockups.
- Retrievalability: How easily decontaminated vs. consumable pieces.
- Environmental: Determine the volume of waste, waste characteristics and limit added waste generated from unplugging methods.
- Safety: Hazard to workers (pressure, temperature, moving equipment). Radiation/contamination concerns.
- Compatibility with current systems: Corrosion, pressure (valves are weak links), utilities (blinds, isolation).
- Operability: How complex, flexible (adaptable to various systems), simple/easy to operate.
- Reliability: Works consistently.
- Maintainability: Easiness to maintain, parts availability.
- Cost: Development cost, capital cost, operating cost.

7. REFERENCES

1. U.S. Department of Energy Office of Public Affairs, “Spent Nuclear Fuel Transportation”.
2. Pipeline Unplugging Technologies Summary, ARC/FIU.
3. Unplugging Of High Level Waste Transfer Pipelines, September 1, 2007 to February 18, 2007. Principal investigator: D. Roelant, Ph. D.