

REMOTE JET GROUTING OF RESIDUAL WASTE HEELS

J.A. Faldowski, M.C. Williams, P.A. Murray
AEA Technology Engineering Services, Inc.

M. Board
AEA Technology plc

ABSTRACT

On completion of bulk waste retrieval operations, tanks may be grouted to stabilize the heel and effect tank 'closure'. The most common method adopted is to pour grout into the tanks through an existing or engineered access. The disadvantage of this approach is that the grout can only be expected to cover the waste heel without mixing the waste and the grout together. The result is a less safe end condition because the remaining waste heel may have pockets still in a mobile form, which could leak into the environment at some time in the future. This is of particular concern in buried tanks and silos where the tank condition is unknown and future leakage or integrity cannot be monitored reliably.

AEA Technology has developed an effective means of using cementitious grout material for in-situ stabilization of residual waste heel material in tanks utilizing Power Fluidics™ technology. The Power Fluidics™ Pulse Jet Mixing system has been used effectively in a number of projects across the DOE complex to mobilize and retrieve tank waste. It has further been determined that the use of this technology may be extended to include in-situ cement grout stabilization of tank waste heels. In 2004, AEA Technology developed a prototype design of a Pulse Jet Mixing system suitable for use in tank waste heel mixing and encapsulation and demonstrated the effectiveness and limits of the technology through a series of trials.

Using inactive simulant materials, the project investigated the technical issues to be addressed in using AEA Technology's fluidic equipment to grout tank heels and to devise and evaluate grout formulations suitable for use in such applications. A suitable grout recipe was initially produced that was compatible with the technology. Aspects of grout performance such as viscosity, setting rate, heat generation, etc. were investigated. A series of small-scale and large-scale trials were conducted on candidate grouts to establish their suitability.

Prototype equipment was then designed, constructed and demonstrated late in 2004, using a mockup of a small waste tank. Tests were conducted to demonstrate introduction of a flowing grout material and mixing of the grout and heel to form a solid homogeneous mass. Both non-destructive and destructive examination techniques were used to determine the effectiveness of the approach. It was also essential to verify that the mixing system can be cleaned following grout introduction for effective reuse or redeployment.

INTRODUCTION

Experience has demonstrated that when retrieving waste from tanks across the DOE complex, there is a point where the limits of a retrieval technology are reached and a small heel is left in the tank. Current tank closure practice is to pour grout into the tank, covering the heel but without attempting to mix the waste and the grout together. The result is that the waste and grout are unlikely to mix and form a homogeneous mass and the remaining waste heel may, therefore, still be in a mobile form which could leak into the environment. Increasingly strict regulatory requirements are making this an increasingly difficult strategy to defend. Consequently, an effective means of carrying out in-situ stabilization (i.e. intimate mixing of waste with grout) for varying quantities of residual waste material in tanks would be of considerable benefit to tank waste retrieval and closure operations throughout the DOE complex.

AEA Technology has previously developed and demonstrated an effective means of mobilizing and retrieving tank waste contents using its Power Fluidics™ equipment. To date, this equipment has been deployed successfully at several tank projects where the work has been completed within the proposed cost and schedule. Adapting this safe, proven and effective technology for carrying out in-situ stabilization of waste heels would represent a considerable improvement to current technology employed in tank closure operations.

This paper discusses the technical issues to be addressed in using this equipment to grout tank heels. The principles of the fluidic Pulse Jet Mixing (PJM) system are described and the requirements for the development of grout formulations suitable for use in such applications is discussed. An inactive waste heel stabilization demonstration program is described, covering the development of a suitable grout formulation and the application of this grout to a waste heel stabilization system using a prototype PJM system. The results of the demonstration program are described.

PRINCIPLES OF FLUIDIC PULSE JET MIXING

Power Fluidics™ Pulse Jet Mixers (PJM's) have been operating in UK nuclear plants since 1970. The technology is proven across a range of fluidic devices and applications and is standard technology in UK nuclear facilities.

All Power Fluidics™ mixing systems use compressed air as the motive force for the movement of the liquid. Each system features an air piston or 'charge vessel' (CV), a fluid reservoir which is filled or discharged by the evacuation or pressurization of the void space above the liquid level. The control of the air into and out of the Charge Vessel is accomplished using a Jet Pump Pair (JPP), designated the fluidic system Primary Controller. The JPP comprises two back-to-back ejector elements. Its purpose is to:

- Supply a positive air flow and pressure to the charge vessel during the drive phase
- Provide a vent path for the air during the vent phase
- Produce a partial vacuum in the charge vessel during the refill phase

The equipment upstream of the Jet Pump Pair is designated the fluidic system Secondary Controller. Its purpose is to:

- Control the duration of the drive phase and to supply compressed air to the "drive" part of the JPP during this phase
- Control the duration of the vent phase and to switch off the air supply to the JPP during this phase
- Control the duration of the refill phase and supply compressed air to the "suction" part of the JPP during this phase

The phase durations are regulated electronically by AEAT's PRESCON™ controller. The PRESCON™ computer both analyzes the input from the process instrumentation and controls the sequencing and operation of the plant. The controller automatically compensates for variations in the system (e.g., changes in liquid level and specific gravity) and so maintains the fluidic system operation at optimum efficiency.

Power Fluidics™ Pulse Jet Mixing System Operation

The PJM system mobilizes waste via a three phase mixing process:

- Suction phase
- Drive phase
- Vent phase

The PJM mobilizes the material contained within the waste tank by first drawing liquid out of the tank into the charge vessel. This liquid is then repeatedly forced backwards and forwards between the tank and the charge vessel (Fig. 1) through an engineered nozzle designed to give a desired flow pattern for the fluid exiting the Charge Vessel. The mixing process is repeated until the tank is well mixed.

The system configuration may also include remotely operated hydraulic^a directional "wash" nozzles which are incorporated into the system above the liquid level in the waste tank. Tank material is initially drawn from the tank to fill the charge vessel as described above. The contents of the charge vessel are then discharged through one of the directional nozzles via a valve manifold. During the drive phase, the liquid jet emerging from the nozzle assists the mixing process.

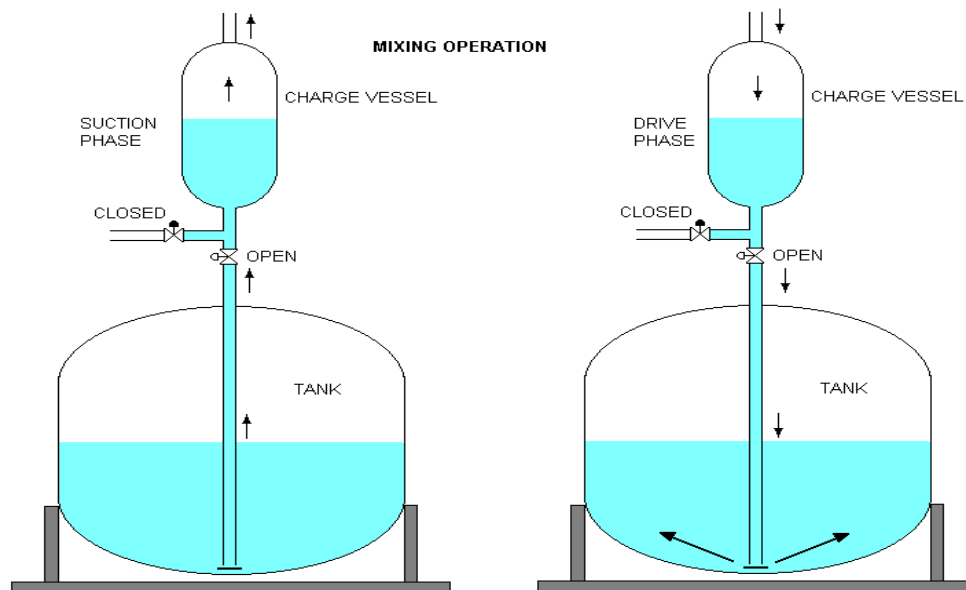


Fig. 1. Fluidic Mixing System Operating Cycles.

GROUT FORMULATION DEVELOPMENT

AEA Technology plc and its forerunners have been at the forefront of UK cementation technology development and performance evaluation for the treatment of radioactive wastes for over twenty years. This study relied heavily on that experience in the development of a suitable grout for stabilization of a tank waste heel simulant.

Two primary considerations are important for the formulation of a grout for stabilizing a waste heel; the grout must have good flow properties for mixing and it must meet applicable standards for waste stabilization characteristics. This section reports how the grout formulation was designed and developed for the inactive demonstration program to:

- Optimize the mixing process by maximizing grout flow and workability; and
- Meet the minimum requirements of the NRC Technical Position for Grouted LLW: Appendix A.

The Formulation Development Process

The design and demonstration of a cementation treatment process for a given waste consists of five interdependent factors. These factors are:

1. Waste characterization: To determine chemical and physical composition of the waste, and potential variability. The waste characterization data are used to make a preliminary selection of a cement formulation, waste loading and process method.

2. **Product specification:** To determine the applicable specification, which will establish product performance targets such as leachability, strength and durability. It is essential that all specification and process criteria are incorporated into the formulation development process at the earliest opportunity.
3. **Formulation development:** To identify an acceptable grout recipe and identify the specification of raw materials used in the recipe. Formulation development work is carried out using methods of increasing scale. Initial work is carried out at bench scale to identify a suitable formulation to treat a waste. Suitability of a formulation includes evaluation of mix viscosity, flow, temperature, setting time and presence of bleed water after setting. Once a suitable formulation is identified, intermediate scale mixes are carried out to produce product evaluation test specimens and to better understand the likely full-scale production process.
4. **Product evaluation:** To test the product performance both on a short time scale (days) and over longer periods (months). The type of tests carried out may include: leachability, strength, durability, dimensional stability and permeability. If the formulation does not meet a specific criterion then the formulation must be modified until the full specification is met.
5. **Process optimization:** In addition to meeting the product specification, the waste treatment process must be practical to operate. This factor is considered throughout the formulation development process and can be demonstrated by carrying out large-scale mixes (e.g. 200 liter) of the finalized formulation.

Specific Formulation Development for Waste Heel Grouting Demonstration

The specific goal of this demonstration work was to develop a grout formulation to immobilize a 40 % solids kaolin clay / water simulant waste heel. This simulant was selected because it is a recognized waste simulant that has been used successfully in previous PJM tank mixing and retrieval development work. The formulation development work was carried out by AEA Technology, Waste Management Technology (WMT) based at Winfrith, Dorset, UK.

The outline waste heel treatment method enabled the basic rheological requirements of the grout and wasteform formulation to be defined:

- The grout was required to have a suitable flow and workability to enable it to be pumped to the tank, and to allow the waste heel and grout to be well mixed by the Power Fluidics™ System. This was achieved by using a high water to cementitious solids (w/s) ratio, thereby minimizing the viscosity of the grout suspension.
- A large volume of grout relative to the volume of waste retained in the tank was required to enable the waste heel to be mobilized and to allow the waste to be adequately mixed with the grout. This was taken to be the case because retrieval efforts using Power Fluidics equipment in the past have drawn the tank down to unmixable levels of less than 2". The addition of grout raises the tank level enough to facilitate mixing of the grout and waste heel together.

- The simulant waste slurry has a high water content (i.e. 60^w/% water), as could be expected in a tank waste heel. Therefore a fluid grout with high waste loading would have had a final product with a high water/solids (w/s) ratio. This would have led to an unacceptably large volume of bleed water, i.e., over standing water on the set product. These factors necessitated that the waste loading of the formulation be kept low, e.g. 10^w/%.
- The final wasteform must meet the minimum requirements of the NRC Technical Position for Grouted LLW: Appendix A (Reference 1).
- Availability of raw materials for grout production must be taken into consideration during the small- scale formulation development work

Selection of materials

The properties of a grout/waste formulation, such as flow and workability, are strongly controlled by the raw materials used (Reference 2). Since the waste heel grouting demonstration was to be performed in the US, to enable the development of a reproducible grout (allowing the effects of raw materials to be understood and minimized), samples of blast furnace slag (BFS), pulverised fuel ash (PFA) and ordinary Portland cement (OPC) available in the US were sent to AEA Technology WMT, Winfrith, UK. Examination of the materials resulted in a PFA/OPC based formulation being selected to treat the simulant waste heel. A 3:1 ratio by weight of PFA/OPC grout was anticipated to have the correct proportions of PFA/OPC to ensure good strength development in the wasteform without excessive heat generation. The selection of a PFA/OPC grout was also preferred to that of a BFS/OPC grout due to the lower density of a PFA/OPC grout. A low-density grout is preferable for maximizing the lift distance in the Power Fluidics™ Pulse Jet Mixer.

Formulation development

The formulation development work was carried out using 150 ml scale scoping trials, 2 liter scale mixes of selected formulations and 200 liter scale pumping tests.

150 ml scale scoping trials: Following the initial assessment of the grout property requirements, small-scale scoping trials were used to investigate the properties of the:

- Kaolin/water simulant waste at 40^w/% solids
- 3:1 PFA/OPC control grout with increasing w/s ratio
- Grout/simulant mixes where the waste loading was increased incrementally at a fixed w/s ratio

Viscosity of the fluid grout and bleed on the set product at 24 hours curing were the two principle grout properties investigated by the 150ml scoping trials. The scoping trials identified the range of w/s ratios at which acceptable (high) grout fluidity and zero / minimal bleed were achieved.

Using the viscosity and bleed data from these trials, a grout with acceptable viscosity, minimal bleed at 24 hours curing and predicted workability was selected for further testing. The selected formulation was a 3:1 PFA/OPC grout, with a w/s ratio = 0.688. This was mixed with the 40^w/_o kaolin slurry to achieve a 10^w/_o waste loading in the final product, resulting in a final w/s=0.80.

Small scale testing at w/s ratios > 0.80 were not carried out as no further significant decrease in viscosity would have been achieved.

2 liter scale mixing: The chosen formulation was further evaluated using a 2 liter scale mix where the grout was continuously mixed for three hours, with samples taken at regular intervals for viscosity and bleed measurements. Previous work has shown that the recirculation of a high w/s grout over several hours reduces the volume of bleed water on the set product at 24 hours curing. The 2 liter mix demonstrated that the formulation had adequately low viscosity, low bleed at 24 hours and excellent workability over a three hour period.

200 liter scale mixing: Following the successful 2 liter scale mix of the above formulation, three mixes were carried out at 200 liter scale. Two mixes were of the 3:1 PFA/OPC with 10^w/_o slurry, w/s=0.80 formulation, and one mix was of the control grout formulation only, 3:1 PFA/OPC w/s=0.688.

The kaolin/water simulant was prepared at 40^w/_o solids in a high shear mixer. The appropriate weight of simulant was then added to a 250 liter capacity holding tank fitted with a low pressure recirculation pump. The appropriate weight of 3:1 PFA/OPC grout w/s=0.688, was mixed in a conventional low shear concrete mixer and added to the simulant in the holding tank. On contact with the grout, the simulant slurry immediately coagulated and the mix could not be pumped. As grout continued to be added to the tank, the extent of coagulation of the simulant waste reduced; after grout addition had been completed the grout / simulant mixture could be recirculated by the holding tank pump. The mix was then recirculated for 3 hours with pipe infill samples taken at 1 hour intervals. Viscosity, flow, and bleed at 24 hours curing were measured on these samples.

The 200 liter scale mix demonstrated that after 2.5 hours of recirculation, the grout and simulant were adequately mixed, (based on visual observation of set samples). The viscosity and flow of the formulation was acceptable and the wasteform samples had no bleed at 24 hours curing.

100mm test cubes and prism samples were taken for non-destructive testing up to 90 days of age and compressive strength testing of cubes at 28 days. These results indicate that the wasteform will meet the specified NRC requirements for cemented LLW.

Conclusions from formulation development work

The formulation development work identified a formulation of 3:1 PFA/OPC with 10^w/_o waste loading, with a final w/s=0.80, as suitable for the treatment of the selected tank waste simulant.

After 2 to 3 hours of recirculation by pumping, the grout and simulant were adequately mixed, the viscosity and flow of the formulation were acceptable, and wasteform samples had no bleed at 24 hours curing. The destructive testing indicated that the wasteform would meet the specified

NRC requirements for cemented LLW when fully cured (i.e. compressive strength at 28 days was approximately 50% of that required for the fully cured product). Data from the grout formulation development work is presented in Table I below.

Table I. Product evaluation data for 300 liter laboratory mix of 3:1 PFA/OPC grout formulation with 10 wt % simulant waste loading, w/s=0.80

100 mm Cube Data						
Sample No	Age (days)	Weight (g)	Pulse velocity (km/s)	Density (kg/l)	Compressive strength at 28 days (MPa)	
1	2	1485.1	1.72	1.49	N/D	
2	2	1494.0	1.71	1.49	N/D	
3	2	1491.2	1.70	1.49	N/D	
4	2	1496.8	1.71	1.49	N/D	
5	2	1487.8	1.71	1.49	N/D	
6	2	1484.8	1.70	1.49	N/D	
7	2	1497.7	1.70	1.49	N/D	
8	2	1494.1	1.70	1.49	N/D	
9	2	1500.9	1.71	1.50	N/D	
10	2	1495.6	1.70	1.50	N/D	
1	28	1478.5	1.86	N/D	1.6*	
2	28	1490.7	1.85	N/D	1.7*	
200 mm Core Data						
Recirculation time (hours)	Core position	Age (days)	Weight (g)	Pulse velocity (km/s)	Density (kg/l)	Bleed at 24 hours (vol%)
1	Top	30	2429.5	1.57	1.45	< 1
	Bottom	30	2355.0	2.04	1.49	
2	Top	30	2435.5	1.77	1.46	< 1
	Bottom	30	2447.0	1.89	1.48	
3	Short	30	2416.5	1.98	1.49	< 1

It must be emphasized that the reaction seen on addition of the grout to the simulant is specific to the use of a kaolin simulant. This result does however illustrate the importance of characterizing wastes to be treated by grouting and the need for careful formulation development when the technology is applied to active wastes.

JET GROUTING OF A SIMULATED WASTE HEEL

The final element of the scope of work performed was to test the feasibility of using a PJM system to mix tank waste heels with the previously formulated grout mixture to achieve a uniformly solidified heel. The PJM system was installed into a framework above a demonstration test tank in the AEA Technology ESI facility in Mooresville, NC.

The specific purpose of the testing was to:

- Demonstrate that a fluidic mixing system can successfully mix grout with a simulated tank waste heel
- Demonstrate that complete mixing of the grout/ waste heel simulant is achieved, leaving no regions of the tank heel 'ungROUTED'

PJM System Configuration

The PJM system was configured in a "typical" arrangement as depicted in Fig. 2 below. The top of the Charge Vessel was 15' above the base of the waste tank. This height was chosen to ensure the maximum depression in the vessel could draw grout with a maximum specific gravity of 2.0 high enough to fill the vessel and also to facilitate gravity draining of the lines back into the tank. A standard "PRESCON™" controller was connected to control the air flow to the Charge Vessel and the sequencing of the mixing phases.

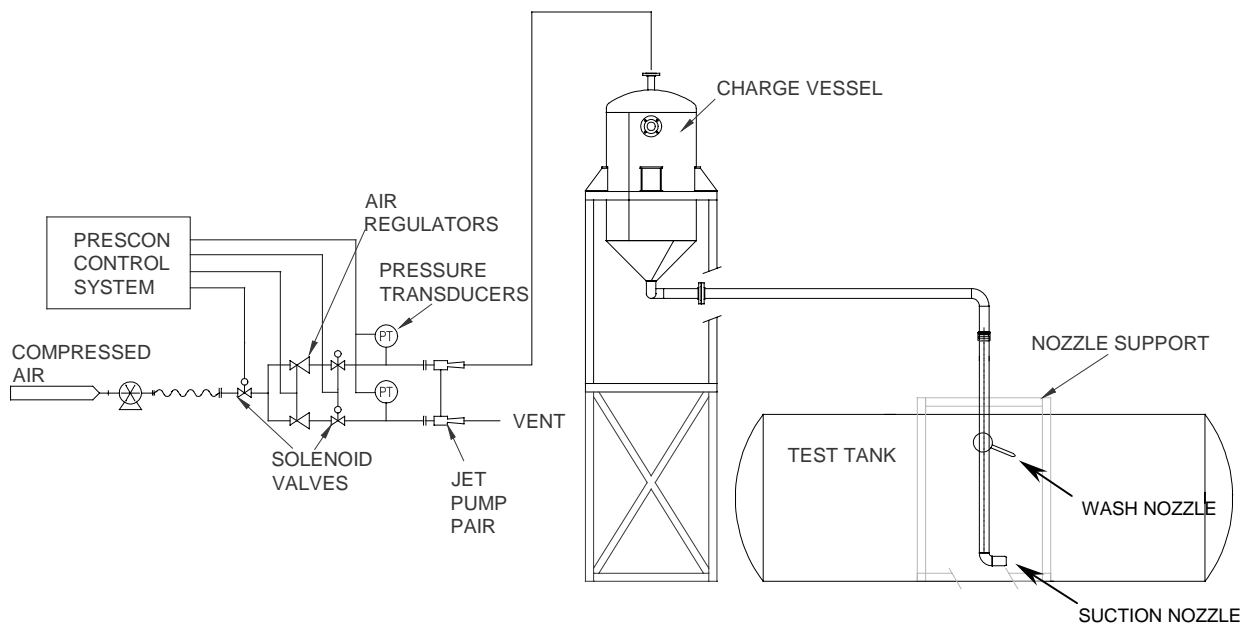


Fig. 2. Test Rig Schematic.

Test Tank

In order to simulate a full-size horizontal tank, a 7500 gallon XLDPPE tank, 102” in diameter and 232” long, was used. A temporary scaffold was constructed over the tank to facilitate instrumentation and equipment deployment through the top of the tank. Access penetrations were cut in the top of the tank to allow nozzles and equipment to be deployed and also to allow access for sampling and viewing.

Nozzle Support Structure

Mixing of the simulant and grout was performed using a rotating suction nozzle and an articulated wash nozzle in a configuration representative of previous site installations. These nozzles were mounted at one end of the test tank. The suction nozzle was mounted so that the inlet/discharge was below the liquid level and utilized a swivel joint to allow rotation. The wash nozzle was a hydraulically controlled articulated nozzle mounted near the top of the tank. The nozzles were supported on a scaffold frame. Rotation of the suction nozzle was done manually for purposes of the demonstration but would be controlled remotely in a field installation.

Charge Vessel

The charge vessel was a 150 gallon ASME, “U” stamped pressure vessel. The base of the vessel was conical to allow complete draining of any entrained material. The grout/simulant is drawn up into this vessel before being discharged back to the tank. Both float style and conductivity probe level switches were used to detect a full charge vessel.

Grout Plant

Mixing of the grout materials and introduction of the grout into the test tank was achieved using a custom built grout mixing and delivery system. The grout mixer consisted of a 200 gallon vertical, cylindrical tank with a conical bottom. A pneumatic mixer with an impeller near the bottom of the tank was used to initially mix the grout. The grout was further mixed by recirculation from the bottom of the tank back into the top of the tank using a 150 gpm double diaphragm pump. Valving was installed on the pump to facilitate delivery of grout to the test tank once the grout was sufficiently mixed. The grout was introduced into the tank via the articulated wash nozzle in batches of 139 gallons. This was done to help facilitate mixing of the grout with the heel upon introduction into the tank.

Test Preparation

Kaolin clay and water was added to the test tank in the appropriate proportions to create a 40 % mixture. 74 gallons (3” depth) of simulant was put in the tank prior to the test demonstration.

Test Execution

Once the simulant was prepared in the test tank, the grout was pre-mixed and introduced into the tank in four batches of 139 gallons each. The total final volume of material in the tests tank was

630 gallons (~13" depth). Following introduction of the fourth batch of grout, the PJM was operated to mix the tank continuously for 3 hrs. A combination of suction and wash nozzle operation was used during the mixing period.

Upon completion of mixing, the pulse tube was removed from the tank and the fluidic equipment was thoroughly flushed. The mixed grout/simulant was allowed to cure for a minimum of 28 days prior to testing. During the initial cure period, the grout was monitored for bleed water formation.

Data Collection

The following data was collected during the test demonstration to evaluate the performance of the PJM and the grout:

- Key parameters from the PJM were recorded during mixing of the grout/simulant mixture including key system pressures and cycle times.
- Qualitative assessment was made of the jet produced by the nozzle, the level of agitation in the tank, the effective range of the nozzle, and the mixing effectiveness of the system.
- The number of cycles required to achieve a uniform appearance of the grout/simulant mixture was recorded
- The grout/simulant mixture viscosity was measured and recorded at one hour intervals
- Temperature in the grout / simulant was measured after the completion of mixing during the first 48 hours of curing
- Grab samples of the grout / simulant mixture were taken from three axial points within the tank at one hour intervals and poured into 4" PVC pipe molds. Analysis of these samples gives an indication of the homogeneity of the grout / simulant mixture at that point in the mixing process.
- After a 28-day cure period, compressive strength, density and pulse velocity were measured. The stabilized tank heel was visually examined and cored to assess the effectiveness of the mixing.

Grout/simulant product performance data from the full-size demonstration is presented in Table II below. It should be noted that the lower compressive strength data from the full-scale demonstration samples as compared to the laboratory samples was anticipated due to the difference in sample geometry (cylinder versus cube). The variability of compressive strength data across sample locations was within the measurement error. The lower compressive strength for the core samples versus the cast samples was due to the flaw introduction during the coring process as was noted by the testing laboratory.

The temperature of the product as it cured peaked at 89°F, 18.5°F above ambient, 15hrs after the conclusion of mixing. The temperature then decayed back to ambient over 8 days. A long cure time and low exotherm were anticipated due to the high w/s ratio in the grout formulation.

Table II. Product evaluation data for full-size demonstration of 3:1 PFA/OPC grout formulation with 10 wt % waste simulant loading, w/s=0.80

In-Process Samples						
Recirculation time (hours)	Sample position	Age for Pulse Velocity and Density (days)	Pulse velocity (km/s)	Density (kg/l)	Compressive strength at 28 days (MPa)	Bleed at 24 hours (vol%)
1	1 (near nozzle)	28	N/D	1.5	N/D	< 1
	2 (tank center)	28	N/D	1.5	N/D	
	3 (end of tank)	28	N/D	1.5	N/D	
2	1	28	N/D	1.5	N/D	< 1
	2	28	N/D	1.5	N/D	
	3	28	N/D	1.5	N/D	
3	1	28	N/D	1.5	N/D	< 1
	2	28	N/D	1.5	N/D	
	3	28	N/D	1.5	N/D	
Cast Cylinder Samples						
3	1	21	1.08	N/D	1.2	N/D
	2	21	1.09	N/D	1.5	
	3	21	1.07	N/D	1.6	
Core Samples						
3	1	41	1.13	N/D	1.5	N/D
	2	41	1.25	N/D	1.1	
	3	41	1.17	N/D	0.9	

CONCLUSIONS

The Pulse Jet Mixing system was proven effective at mixing the grout/ waste simulant mixture to achieve a uniformly solidified heel. Visual observation indicated that the combination of the nozzle near the bottom of the tank and the “wash” nozzle near the tank top introduced sufficient mixing energy to produce good mixing in all areas of the tank. There was minimal bleed water in the hours immediately following mixing and none on the set product at 24 hours curing. A comparison was made of the heel condition after adding the grout but before mixing to the mixed end state of the heel. This is documented in Fig. 3 below.

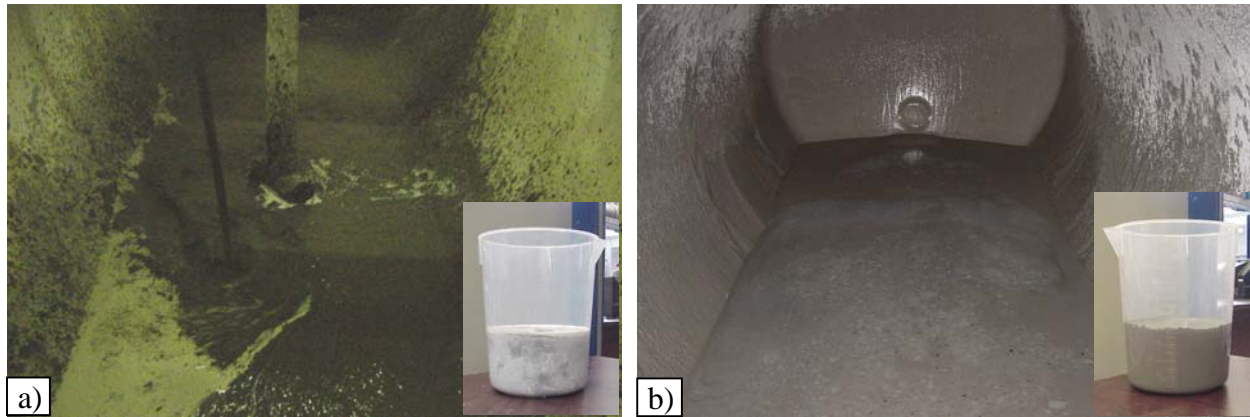


Fig. 3. Bench scale (inset) and demonstration trials of: a) grout poured on top of simulant waste without mixing and b) grout mixed with simulant waste.

Mixing System Performance

The mixing system performed as expected. The first two cycles were necessary to break up the coagulated grout/simulant material and obtain a fluid mixture. Following that, the system performed similarly to previous mixing campaigns to mobilize existing tank heels. The jet produced by the pulse tube nozzle produced effective mixing throughout the tank and the entire contents appeared homogenous after five to ten cycles (~30 minutes). The key parameters monitored (most notably suction time) changed only slightly over the three hour mixing time indicating a trend toward higher viscosity as mixing progressed. This change did not affect mixer performance but may provide an in situ indicator of product rheology in field applications (See Fig. 4). Following the mixing trial, the system proved moderately difficult to clean. The waste lines could be cleaned by flushing with water. However, the charge vessel and level switches required pressure washing to remove grout solids. Modifications to the system design are possible to eliminate/greatly reduce buildup of grout on crucial system control components.

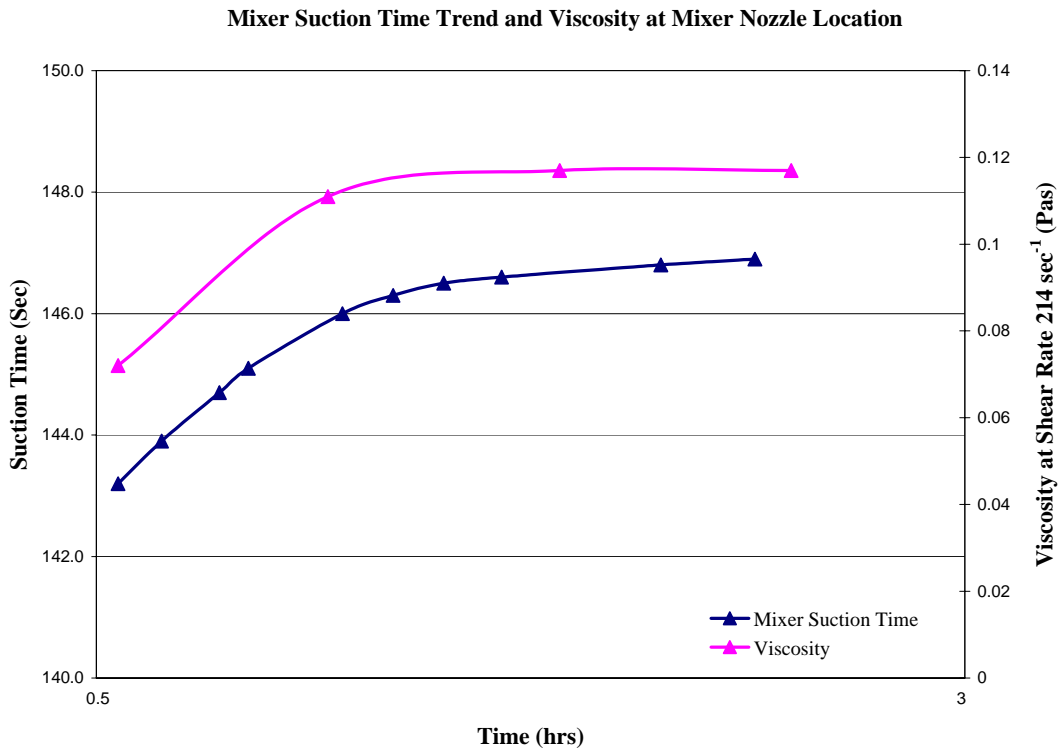


Fig. 4. Fluidic Pulse Jet Mixer suction time varied with the viscosity increase in the mixed product.

Implications for future work

The demonstration proved the efficacy of using a Power Fluidics™ Pulse Jet Mixer for mixing specially formulated grout with a simulated waste heel. The benefits of this approach include:

- A greatly improved waste end state, wherein contaminants are mixed and stabilized in a grout matrix rather than unmixed with pockets of mobile contaminants remaining.
- A final waste form that meets current US regulations for grouted LLW.
- Utilization of a single system for bulk waste retrieval and heel stabilization resulting in lower radiation dose to workers, decreased capital equipment costs, lower labor costs for field activities, and a consolidated approach to safety documentation preparation.

It should be emphasized that application of this technology to an active tank waste heel must include development work initiated as early in the process as practical.

The grout development work should include:

- Characterization of the waste heel
- Development of a representative simulant
- Formulation of a grout for the simulant with the broadest effective design envelope possible

- Complete testing of the grout/simulant mixture against applicable governing regulations
- Testing of the grout with a sample of the active heel material (when possible to do so)

Mixing system development work should include:

- Access options to the tank (e.g. number and size of current risers, etc.)
- Waste tank geometry (e.g. tank size, configuration, in-tank obstructions, etc.)
- Retrieval / Operational strategies to be employed (e.g. in-tank nozzle disposal, off-gas treatment, method of grout addition, etc.)
- Consideration of the site elevation with regard to Charge Vessel elevation above the waste tank
- Sampling requirements and methods
- System cleaning and decommissioning requirements

It is anticipated these successful trials will provide a basis for development of field deployable equipment. Adapting this safe, proven and effective technology for carrying out in-situ stabilization of residual tank waste material has the potential to be of considerable benefit to tank waste retrieval and closure operations throughout the complex.

REFERENCES

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FOOTNOTES

^a Advanced nozzle designs recently developed by AEA Technology incorporate the use of electrically driven actuators in place of the hydraulic system. This has the benefits of a slimmer equipment profile to fit inside existing tank penetrations, enhanced position control, and elimination of the need for hydraulic fluids on the site.