PHOSPHATE/SULFATE WASTE GROUT CAMPAIGN REPORT

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ABSTRACT

The grout facility, which is managed by Westinghouse Hanford Company for the Department of Energy, processed one million gal of low-level radioactive waste into a final-disposal form. The Phosphate/Sulfate Waste (PSW) campaign was initiated August 30, 1988, as part of Westinghouse Hanford Company's defense waste disposal program. The facility was restarted in April 1989 and again in June 1989 to complete processing 1,001,000 gal. Several deficiencies were identified during this campaign. The final operation of the facility in June 1989 successfully demonstrated the ability of both the Dry Materials Facility (DMF) and the Transportable Grout Equipment (TGE) facility to support conversion of low-level liquid wastes to grout slurry and subsequent transfer to a near-surface concrete vault for solidification and disposal.

HIGHLIGHTS

Campaign start date:	August 30, 1988
Campaign completion date:	July 11, 1989
Start of construction:	DMF - May 1985
	TGE December 1986
	Vault December 1986
Completion of construction:	DMF - July 1986
	TGE December 1987
	Vault January 1988
Yards of concrete used in the vault construction:	3100 yd^3
Waste processed:	1,001,000 gal
Dry materials used:	4,117 t
Raw water used:	92,269 gal
Tributyl phosphate used:	474.6 gal
Vault size:	125 ft x 50 ft x 34 ft
Vault space used:	125 ft x 50 ft x 30 ft
Operating personnel:	11 operators, 3 managers, 3 process engineers
Facilities cost:	DMF $3.8 million
	TGE 9.0 million
	Vault 2.9 million
	Site 2.0 million
	TOTAL $17.7 million
TGE On-stream time:	August 1988 12%
	April 1989 32%
	June 1989 82%

INTRODUCTION

The grout facilities consist of four major structures. The 241-AP-102 waste feed pump pit and transfer piping, the Dry Materials Facility (DMF), the Transportable Grout Equipment (TGE) Facility, and the Grout Disposal Facility.

Waste Feed

The liquid waste feed is stored in one million gal tanks, at the 241-AP Tank Farm, while feed characterization is performed. Once characterized, the feed is pumped to the TGE facility for treatment and ultimate disposal. The waste feed used for the first grout campaign was low-level spent decontamination solution Phosphate/Sulphate Waste (PSW) from the N-Reactor, which produced a nonhazardous solid grout matrix.

Dry Materials

The cementitious materials used in the grout treatment process were blended at the DMF. The materials used were Cement @ 41 wtpercent, Fly Ash @ 40 wt%, Attapulgite Clay @ 11wt%, and Potters Clay @ 8 wt%. The blended material was transported by truck trailers to the TGE facility in 25 t shipments.

Transportable Grout Equipment

The TGE facility mixed the cementitous materials with the liquid waste at a ratio of 7.5 lbs/gal, to create a grout slurry. This slurry is pumped via encased piping to an underground-disposal vault. The only additive introduced during the PSW campaign was Tributyl Phosphate (TBP), used as an air de-entrainer to minimize foaming.

Grout Disposal Vault

The grout disposal vault consists of a double-lined concrete box approximately 125 ft long, 50 ft wide and 34 ft deep. A leachate detection/collection and removal system is provided to contain any liquid which may escape the bounds of the liner system. Instruments are provided to monitor the grout temperature and level.

OPERATIONAL DATA SUMMARY

Run Summary

The PSW campaign was conducted in three stages.

The initial startup of the TGE facility on August 30, 1988, identified design deficiencies with the surge tank vent system. The facility continued to process 367,000 gal of waste feed to gain experience and collect operational data with the process equipment until October 21, 1988.

The additional design was implemented in the field by April 1989 and the facility restarted on April 13, 1989. The restart of the facility demonstrated the adequacy of the design modification to resolve the surge tank vent system design deficiency. The facility continued to process 133,000 gal of waste until April 27, 1989. This completed the first half of the campaign (500,000 gal of waste feed processed).

The facility was restarted again on June 19, 1989, on schedule, to complete the campaign. The facility continued to process 600,000 gal of waste feed (1.001 millon gal total), until July 11, 1989.

Essential Materials

Rail Car and Truck Unloading: The dry materials to be blended into the grout formulation were received at the DMF by railcar and by truck. An effort was made to have all clay materials delivered by truck rather than railcar for the second-half campaign. This was an attempt to avoid some of the unloading problems encountered previously with the railcars.

The dry blend was gravity fed from the day bin into the mixer at a nominal rate of 338 lb/min (7.5 lb/gal ratio). Redundant flow instrumentation ensured that the proper amount of blended material was delivered into the process. A discrepancy of greater than 25 lb between the redundant weight transmitters required a process shutdown to determine and resolve the discrepancy.

Grout Processing

The waste feed was combined with the dry blend in the mixer module to form a cementitious slurry at a nominal rate of 65 gal/min. The slurry, once mixed, was pumped to the disposal vault for permanent disposal.

Additive System

The PSW campaign used Tributyl Phosphate at a nominal rate of 0.02 gal/min as an air de-entraining agent. The surge tank and the disposal vault have the potential for air entrainment from the free-falling grout in addition to the foaming nature of the phosphate/sulfate waste.

Ventilation System

The process ventilation system at the TGE consists of redundant supply air handling and exhaust filtration units. The exhaust units contain nuclear-grade High Efficiency Particulate Air (HEPA) filters. The exhaust unit exhausts air at 600 scfm from the mixer module and 100 scfm from the surge tank vapor space to provide a slight negative pressure in the module to maintain confinement. The air leaving the surge tank is routed through a bag filter located in the bag house on the day bin tower. The bag house filters remove excess dry blend collected from the surge tank vapor space and recycle the dry blend back into the mixer unit.

The exhaust HEPA filters were replaced to provide analytical information to support the development of a safety analysis report. The filters were replaced and analyzed in the field on November 22, 1988. The resultant gamma energy analysis indicated that Co-60, Cs-137, Eu-154, and Am-241 were present in the amounts of 3,828, 454, 2,259, and 7,615 nCi respectively.

Computer Control

The TGE process is controlled by a General Electric programmable control system. The operators interface with the programmable control system through a computer keyboard. Commands are input into a graphic representation of the process, and process parameters are displayed as changes occur. Process parameters are also stored in retrievable computer files by a data logging system which scans the parameters and extracts preselected data points at a preset frequency. The data logging capability proved to be useful to look back and observe how the different parameters reacted to the event in question. The data logging has also proved useful for the monitoring and long-term tracking of the processed-grout temperature profiles in the vault.

During the course of the campaign it became necessary to make some changes to the software which controlled the computer system. A time delay was added to the alarm/interlock circuits to prevent false alarms due to electrical spikes/interference, and the vent line re-design required some software modifications for control of the new heaters.

Grout Disposal Facility

Vault Levels: The final surface levels are presented on a three dimensional graph, as shown in Fig. 1. The volume of excess water and processed grout were calculated at 5,990 ft^3 (44,800 gal) of liquid and 184,136 ft^3 (1.37 million gal) of grout. The campaign generated 39,952 gal of flush water. The difference between the excess-water volume and the total-flush water used, is attributed to the phase separation during the grout process and equals 4,848 gal or 4.8 percent of the grout volume.

The data shows that the grout tends to flow from the center outward to the corners, leaving the center area

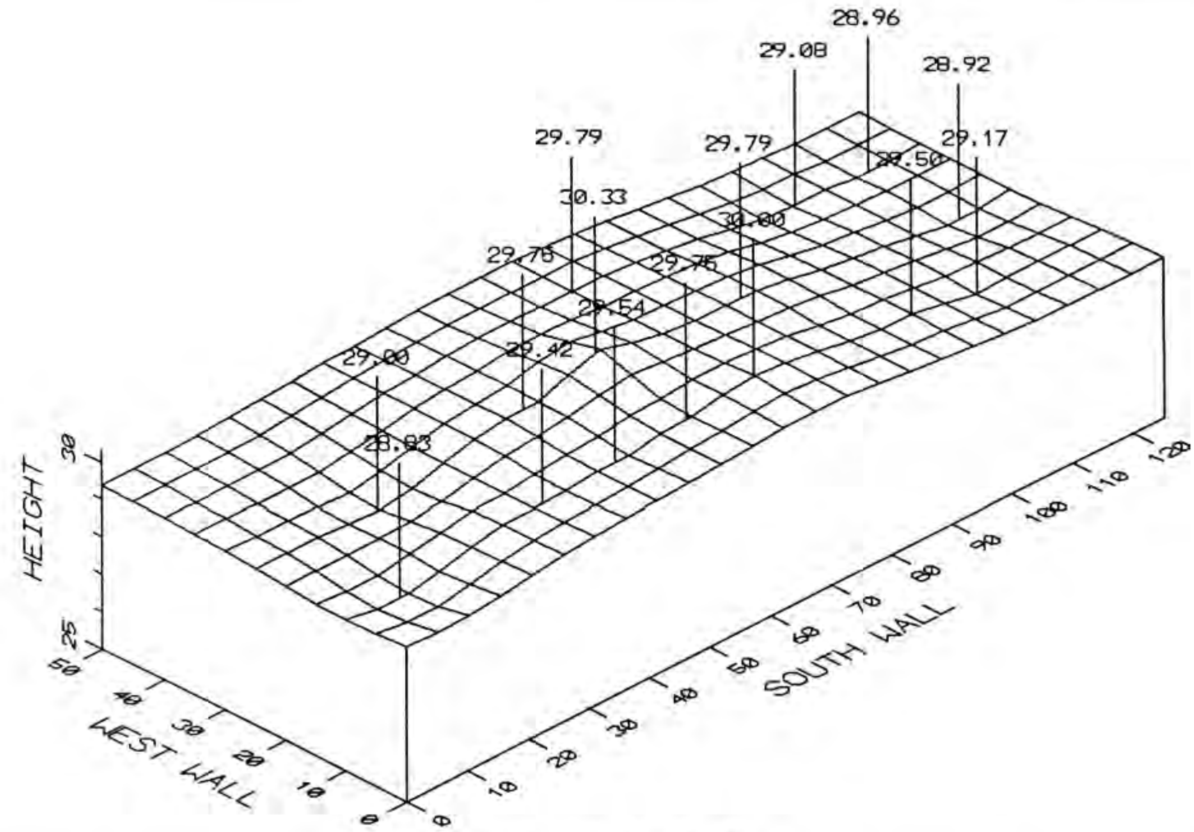

Fig. 1. Grout Surface Profile.

slightly mounded. The slope was determined to be approximately 1.5 percent from the center to the corners.

Vault Leachate

The vault leachate-removal system required periodic operation. Leaks in the primary liner caused excess water to drain into the leachate collection sump. The solution collected in the leachate sump was allowed to reach 3 ft in depth (approximately 1,080 gal) before the level alarm sounded in the control room and actions were initiated to begin removal. The collection sump capacity is larger; however, the hydraulics of the vault system require that the leachate level is always below 5 ft to avoid backing up solution between the liners. The solution in the collection sump was recycled back into the vault on top of the grout.

Following the completion of the campaign's last stage, the leachate collection increased to a rate that required leachate to be recycled to the vault several times per shift. At this point it was decided to pump the leachate back to the feed tank, rather than recycling the solution to the vault. Approximately 51,000 gal of leachate were removed. This immediately reduced the collection rate to approximately 10 gal per day. The rate has decreased further and has leveled off at approximately 4 gal per day.

Grout Temperatures

The average grout temperature in the vault along with grout levels is presented in Fig. 2. The average temperature is a computer generate average of the temperatures measured by the thermocouples submerged within the grout.

The computer uses a grout level indicated by the level probes for this average.

The average temperature is useful in trending the total grout mass with respect to the process operation, as reflected in the changing vault grout level. The actual temperature is higher due to approximately two ft of ambient air above the grout surface, which is averaged in to the overall grout temperature by the computer. The actual grout temperature initiated at 82°F and reached a maximum of 149°F. All temperature data was logged by the computer data logging system at TGE and has been downloaded and archived. The ambient air temperature above the grout surface is approximately 80°F to 85°F hile the grout temperatures are in the range of 95°F to 120°F.

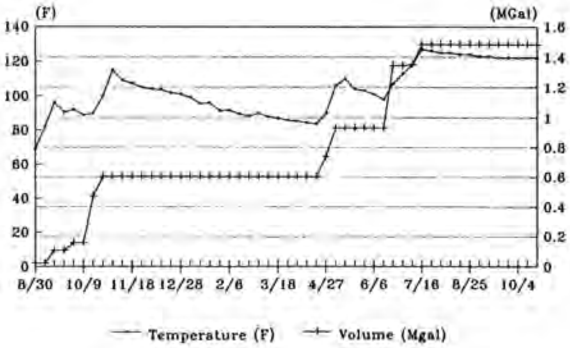

Fig. 2. Average Grout Curing Temperature.

The grout tends to rise in temperature on initial curing and then begins to cool off as curing progresses.

Quality Verification

Two types of samples were obtained from the vault during the first half of the campaign. The first type of sample was a grout slurry sample. Three slurry samples were obtained by dipping a wide-mouth sample container (bottle and string method) into fresh grout, utilizing one of the risers near the center of the vault. These slurry samples confirmed full scale solidification.

During the second half of the campaign, two types of in-place testing were planned for the grout. In-place grout sample collection (twin tube) devices and in-place density monitoring (pulse velocity) devices were installed. These devices were installed to demonstrate and verify the quality of the proposed techniques.

The twin tube samplers, designed and installed by Pacific Northwest Laboratories (Battelle) of Richland, Washington, allowed grout to fill an inner tube and cure. Once the grout became solidified, the inner tube was extracted from within the outer tube and removed from the vault. The solid-grout core within the inner tube was removed and prepared for analysis. The cores demonstrated that all compressive strength and leachability performance criteria were met.

The pulse velocity transducers were installed by Olson Wright NDT&E, Inc of Lakewood, Colorado. The intent of the monitoring was to demonstrate a relationship between grout solidification and the density as seen through the pulse velocity. Preliminary data indicate defendable correlations between pulse velocity measurements and solidification criteria.

OPERATIONAL PROBLEM SUMMARY

Dry Materials Facility

Flow Control Problems: During processing of the first few batches, several automatic valves would not actuate smoothly, sometimes resulting in out-of-tolerance batches. These batches were manually adjusted to conform with specifications.

The knife gate valve opening which regulates the flow of material from the storage bin was too large. Batch processing was stopped to adjust the knife gate settings, whereupon blending activities resumed.

Inspection of a bin manual isolation slide gate valve revealed dry-material buildup in the gear box, jamming the valve and preventing movement. A new seal was designed that would prevent material from entering the gear box. The design was implemented and proved inadequate. A replacement valve has been identified which locates the gear box outside of the material flow. The new valves will be installed before the next campaign and should resolve the material buildup problem.

Vibrating Screen

During the second half of the campaign, the mounting bolts, which connect the screen to the vibrating mechanism, sheared off because of material fatigue. A larger mesh screen without vibrating action was temporarily installed and successfully operated. Efforts are under way to identify a permanent replacement for the vibrating-screen mechanism for use in future campaigns.

Transportable Grout Equipment

Surge Tank Vent Line: The initial operation in September identified a significant problem with the surge-tank vent line. After approximately 25 to 30 h of operation, the vent line would plug up. The obstruction was found in the elbow connected directly to the surge tank and consisted of unmixed dry blend in the air stream and moisture from intermittent water sprays in the surge tank, and mixer chute. In the course of troubleshooting the plug, another serious problem was found: over 50 per cent of the vent line exterior-band strip heaters had failed.

The first half of the campaign operation was suspended after processing only 367,000 of the scheduled 500,000 gal of waste feed. The remaining 133,000 gal were reserved for conducting tests to demonstrate the performance of any new designs.

A new design, prepared by US Ecology (the original design/construction firm), was installed, which eliminated the strip heaters and added a separate pipe with an in-line resistance heater to introduce a heated air supply to the surge tank. The key to their redesign was a transition plenum which mixed the hot, dry air supply with the surge-tank air at the vent pipe/tank interface. This high-speed, hot-air mixing prevented any moisture/dry-blend coating on the piping. The new heater design was installed in April 1989, and the operation was restarted to process the remaining 133,000 gal of waste left from the first-half campaign. The remaining waste was processed without any further incident. Subsequent inspection of the surge tank after the April and July operations showed no material buildup in the piping elbow.

Surge-Tank Level

The surge-tank level control is based on liquid-level monitoring using a capacitance probe. Redundant-level monitoring is provided with a standard air bubbler assembly. The option of controlling from either level-monitoring system is available; however, the capacitance system is used because previous test results demonstrated that this system has a faster response.

Shortly after initial operation, a discrepancy was observed between the two-level-monitoring systems. The discrepancy started at a few gal and would gradually increase to a 30 gal difference with the capacitance system indicating the higher level.

Periodic equipment sprays (5-10 sec every 20 min) inside the surge tank would return the discrepancy to the initial few gal; however, the gradual increase would continue. This caused concern, because it could not be proven which level-monitoring system was correct.

A contributing problem was the inability to maintain a smooth waste-feed flow caused by low-feed pressure. The startup procedure was modified to clarify the steps that ensured that the waste-feed pressure was greater than 40 psig. This stopped the cycling-flow valve and helped stabilize the surge-tank level. The wide swings in level discrepancies were moderated; however, the discrepancy still existed.

As part of the system evaluation, the capacitance probe was removed from the tank, attached to a spare transmitter assembly in the shop, and tested in a 55 gal drum. Water tests showed that water splashing on the probe did not appear to spike the output. When the drum was filled with water grout, splashes of grout on the probe were clearly seen as output spikes on the transmitter but did not show up as a continual baseline change. It was concluded from this small test that processing shutdowns were highly probable from splashing grout activating the high-high interlock, but that a large and solid buildup was needed for a baseline error.

No other change was made until after the April operation, when the level discrepancies between the two probes, and a significant number of apparent high-high interlock shutdowns were again seen. The entire probe was replaced. During the replacement it was found that the probe had a loose electrical connection at the head. In addition, a delay timer in the software was used to minimize any spike effects or interlocks. Lastly, a routine slow blowdown of the bubbler dip tubes was initiated. These changes produced stable, consistent flow indication on both probes during the entire July operation, and eliminated process shutdowns from surge-tank-level spike interlocks.

Grout Pump

Upon attempting to restart the facility in April 1989, after a six-month shutdown period, the pump packing began to smoke. Removal and examination of the packing material revealed that the grease used to lubricate the packing material had hardened on the material surface, thereby stopping the spring activated lubrication cup from functioning. Even though the packing was replaced, the lubrication cup/spring only worked sporadically, forcing the manual pumping of grease into the packing twice during the April run. No problems were seen during the second-half campaign in July; however, efforts are underway to redesign the remote lubrication system.

Grout Buildup in Process Equipment

The interior pipe diameter of the grout pump discharge elbow outlet, and the interior of the grout pump suction cavity, were inspected for grout buildup in February 1989 and October 1989. No significant buildup was noted in the February inspection. Some hardened grout was seen in the corners of the suction cavity and diameter measurements of the piping were obtained. The latter inspection, however, found significant buildup (0.172 in. total wall buildup) in the piping and a large amount of buildup in the grout pump suction cavity. The first inspection was made after the August/September production run and hence had many flushes. The inspection in October followed the April run and July run where two-thirds of the grout was produced with minimal flushes. The results here could be skewed by the 10-12 lb/gal mixture made for approximately 30 min during the April run. However, they are indicative enough to warrant a spray-nozzle modification to the pump-inspection plate and further development of a grout decon solution. The interior of the surge tank was also inspected in October 1989 with no grout buildup seen in the tank or on instrumentation in the tank.

Grout Disposal Facility

Vault Cameras: Several equipment problems were identified with the vault camera system. The closed-circuit camera system caused electrical interference with the process-control system. The camera lighting was identified to have an extremely short life span, the pan and tilt mechanism failed, and the camera focus drifted as the camera zoom mechanism was operated. The electrical interference was corrected by installing terminating resisters on the camera system electronics. The pan/tilt and zoom problems were repaired mechanically and a new 12 volt power supply design (instead of the 110 volt) is being implemented to increase bulb life and illumination.

Vault Capacitance Probe

The manual measurements of the grout and liquid levels provided data for comparison to the in-place, capacitance based, level probes. The data confirmed suspicions that the in-place level probes were inaccurate. The level probes consistently indicated higher levels than actual measurements support. Troubleshooting the probes identified that the discrepancy is probably caused by grout material shrinking away from the probe. Since the probes cannot be maintained by the nature of the installation, a different type of retrievable probe is being considered for future vault construction (e.g. sonic probes).

CONCLUSION

The initial startup and operation of the grout treatment facilities identified additional equipment and process deficiencies which were not identified during testing. The major deficiency was involved with the vent line from the surge tank. The vent line would plug with grout material after 20-30 h of operation. A design change was implemented that introduced hot-supply air into the surge tank. This eliminated the grout material buildup in the vent line and allowed the facility to continuously operate during the second half of the campaign.

The facility successfully demonstrated that the grout treatment process is a viable method for the permanent disposal of low-level radioactive liquid waste. This method will be used to permanently dispose of low-level waste stored at the Hanford Site in underground tanks.