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Development of a Mechanical Based System for Dry Retrieval of Single Shell Tank Waste at Hanford

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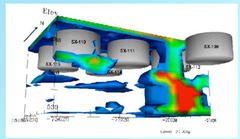
washington river protection solutions

INTRODUCTION

- Current retrieval methods for sludge and saltcake require significant amounts of water for retrieval (> 55,000 gal)
- Using large amounts of water makes it increasingly difficult to allocate space in the receiving double-shell tanks
- Several methods have also reached their "limits of technology" before reaching the residual waste volume goal of 30 ft^3 for 200 series tanks and 360 ft^3 for 100 series tanks

PROBLEMATIC TANKS

Air-Lift Circulators in AX tanks at Hanford



Leaking SX Tanks Data

DOE/ID/12584-268, GJPO-HAN-4, Vadose Zone Characterization Project at the Hanford Tank Farms, SX Tank Farm Report, September 1996

- Need to address retrieval technologies for problematic tanks
- For 67 leaking SSTs, little or no water can be added to dislodge or mobilize waste without exacerbating the leak
- Several tanks contain air-lift circulators where an arm-based retrieval would not be possible
- There are sixteen 200-series tanks with a 20-ft diameter where an arm-based system could not be deployed
- Utilize existing risers to reduce risk of contamination
- ***No dry retrieval methods are currently available***

PAST RETRIEVAL METHODS

Tank	Primary Waste Type	Retrieval Technology(ies) Deployed	Residual Waste Volume (ft^3)
C-103	Sludge	Modified Sluicing	338
C-104	Sludge	Modified Sluicing/Hot Water Dissolution	657
C-106	Sludge	Past Practice Sluicing, Acid Dissolution	370
C-108	Sludge	Modified Sluicing	1029
C-109	Sludge	Modified Sluicing	1150
C-110	Sludge	Modified Sluicing	2300
C-111	Sludge	Modified Sluicing	4300
S-102	Saltcake	Modified Sluicing	12400
S-112	Saltcake	Modified Sluicing, Remote Water Lance, Caustic Addition	319
C-201	Sludge	Vacuum Retrieval	19
C-202	Sludge	Vacuum Retrieval	19
C-203	Sludge	Vacuum Retrieval	18
C-204	Sludge	Vacuum Retrieval	18

Data derived from HNF-EP-0182 R264, "Waste Tank Summary for Month Ending March 21, 2010," Washington River Protection Solutions, LLC, Richland, WA, 2010.

- Modified sluicing removed the majority of liquid, saltcake, and sludge, but leaves a substantial amount of hard heel waste
- Aluminum makes up 92, 50, and 79 percent of hard heel waste volumes in SSTs C-103, C-108, and S-112 , respectively
- The recycled DST supernatant used in modified sluicing contains a high concentration of sodium
- Supernatant does a poor job of dissolving the low-soluble salts in hard heel waste

RESULT: Hard heel waste left after sluicing contains high concentration of aluminum and low-soluble sodium compounds

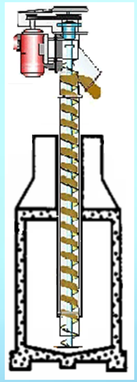
Residual hard heel samples from PNNL of tanks C-103, S-112, C-202, and C-203

Photos derived from "Hanford tank residual waste – Contaminant source terms and release models" Applied Geochemistry, Volume 26, Issues 9–10, September–October 2011, Pages 1681–1693

DRY RETRIEVAL

The success and feasibility of vertically conveying single-shell tank waste is almost entirely dependent on the moisture content of the waste. Waste with 10% moisture or less will work best with a vertical screw conveyor

VERTICAL SCREW CONVEYOR



- Ideally suited to convey a variety of materials
- Less sensitive to variability in flow rate, consistency, or content
- Entirely enclosed, allowing fully contained waste transfer without spillage
- Few moving parts, low maintenance
- Can be operated remotely
- Can be designed to utilize existing risers

SCREW DESIGN FACTORS

Clearance between screw and shaft

Free length of intake

- The radial clearance C needs to be at least 1.5 times larger than the maximum particle size in order to prevent jamming of particles in the clearance space.
- To prevent excessive slip back and loss of efficiency at a 90 degree angle of elevation, the clearance needs to be limited to a maximum value of 3 times the maximum particle size.

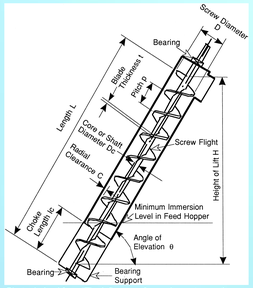


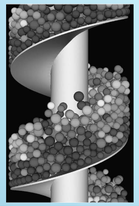
Photo derived from "The influence of granular vortex motion on the volumetric performance of enclosed screw conveyors" Powder Technology, Volume 104, Issue 1, 3 August 1999, Pages 56–67

SCREW CAPACITY FACTORS

Particle Size

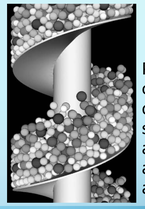
Bulk Density

Particle Density



Particle Flow

Particles are colored by their speed: from light grey to dark grey for 0.4 to 0.9 m/s.



Particle Distribution

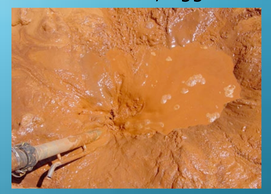
Particles are colored by diameter: smaller ones are light grey and larger ones are dark grey.

Photos derived from "Prediction of screw conveyor performance using the Discrete Element Method (DEM)" Powder Technology, Volume 193, Issue 3, 10 August 2009, Pages 274–288

VACUUM EXCAVATION

- Air-vacuum excavation loosens the soil with a blunt-nosed high pressure air lance and immediately vacuums away loosened material
- The waste properties affecting the solids suction by a transfer pump are the density and the viscosity of the liquid and the size and the density of solids for a non-cohesive solid
- For a cohesive solid, the critical shear stress is not only a function of these four waste properties, but also of the cohesiveness of the solids and its history and condition.
- There are no reported measurements of critical shear stress for Hanford waste.

SV60V and SV110V pumps (SUPAVAC Canada) can function as a high lift vacuum and transfer dry sand and thick, aggressive sludges.



MECHANICAL END EFFECTOR

AUGER DREDGE

- Uses an auger flighting to guide sediment into the mouth of a suction intake
- Basic rotational action keeps material moving along the threads of the screw, and well-machined edges help gather as much material as desired
- Can be used as a robotic crawler or an end effector to break up sludge and saltcake as it is vacuumed out of the tank

PITHOG Robotic Crawler Dredge