Mobile Fluidic Tank Waste Retrieval Equipment for TA21 Generals Tanks

System Overview

Prepared for the

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1 Contents

2 INTRODUCTION

This document sets out AEA Technology Engineering Services, Inc. (AEAT) proposed technical approach to the mixing, sampling and retrieval of waste from the TA21 Generals Tanks. The document is an overview of the system design and operations strategy that AEAT will develop this FY for recovering the waste from the tanks by redeploying the fluidic equipment previously supplied to LANL by AEAT in 2002, now deployed at TA50.

Under combined site/DOE HQ funding AEAT designed and manufactured mobile fluidic tank waste retrieval equipment for use in retrieving tank waste at the LANL site. This equipment was installed at TA-50 in 2002, and used in 2003 to retrieve waste sludge from the TA50 sludge tank. It is expected that some time may elapse before the equipment is needed again to retrieve waste from the influent tank at TA50.

This equipment will be relocated to TA21 and modified as specified herein for retrieval of waste from the generals' tanks. This document outlines strategies for relocating the equipment, modifying it for use in the general's tanks and tank modifications in order to carry out sampling and retrieval operations.

Subject to agreement of this technical approach, AEAT will develop a detailed design of new in-tank equipment and modifications to the equipment currently deployed on site.

3 References

1. Engineer-In-Training Reference Manual. 8th Edition. Michael R, Lindeburg
2. “Charge Vessel Skid Arrangement –Mobilization & Transfer System – LANL” AEAT Drawing 2121-1-029 Rev. 02 Sept. 12, 2002
3. “Charge Vessel Details –Mobilization & Transfer System – LANL” AEAT Drawing 2121-1-020 Rev. 02 Sept. 10, 2002
4. “Installation No 1, Tank Site (DPW-107)(DPW-108)” L.A.S.L Dwg No. ENG-C 2076, Sheet No. 1, File No. PE 202

4 Principle of Operation of Fluidic Mixing and Retrieval System

4.1 GENERAL MIXING PRINCIPLES

The Power Fluidic pulse jet mixer process is designed to mix sludge with existing supernatant or added liquid to homogenize and mobilize sludge and liquid waste. The mixer system also has the ability to transfer waste via a discharge line to a waste receipt facility and provides a means of taking a sample of the waste at any point during operations. The major components of the system are:

- Charge vessel **–** pressure vessel which acts as a reservoir for the system
- Suction tube – pipe in the tank used to suck the tank contents into the charge vessel and discharge them back into the tank for mobilization
- Jet Pump Pair - provides the gas pressure and flow conditions in the charge vessel and acts as a barrier between the clean incoming compressed gas and the potentially hazardous liquid
- Valve skid - handles only clean gas and provides the gas flow to the jet pump pair as required
- Remote directional nozzle system for wall washing

The pulse jet system mixes the sludge and supernatant liquid using a three phase mixing process as detailed below:

- Suction phase
- Drive phase

- Vent phase

4.2 MOBILIZATION MODE

During the suction phase, the jet pumps are used to create a partial vacuum in the charge vessel, which in turn draws liquid up from the storage tank into the vessel. This is shown in Figure 1

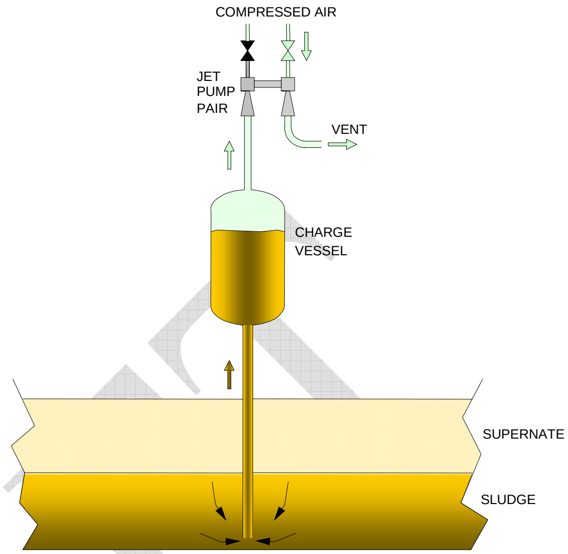


Figure 1: Suction Phase

Once the charge vessel has been filled with the liquor, the jet pumps pressurize the charge vessel, which drives the liquor back into the storage tank, agitating the contents of the tank and re-suspending settled solid particulates into the supernatant liquid. This is the drive phase and is shown in Figure 2.

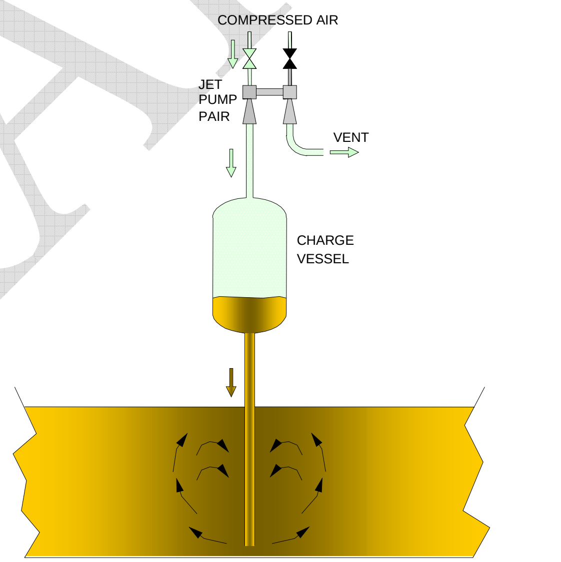


Figure 2: Drive Phase

When the liquor levels have reached the bottom of the charge vessel, the drive phase is terminated and the charge vessel is depressurized through the jet pumps in the vent phase. This is shown in Figure 3. The cycle is then repeated until the sludge and the supernatant liquid have been mixed.

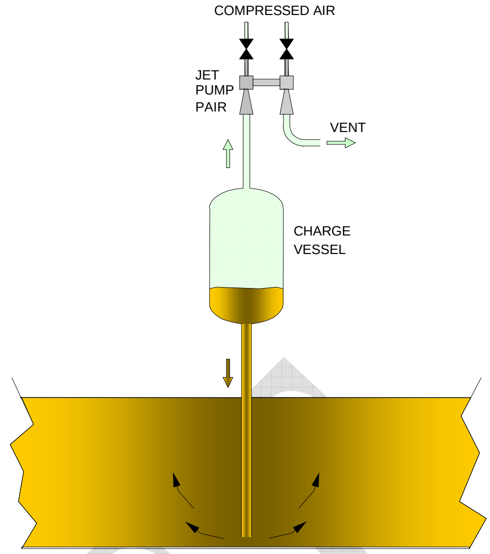


Figure 3: Vent Phase

4.3 TRANSFER MODE

The diagram below illustrates a system which is capable of transferring the contents out of the tank; a transfer line is added below the charge vessel.

During the suction phase, the jet pumps are used to create a partial vacuum in the charge vessel, which in turn draws the mixed slurry up from the storage tank into the vessel. This is shown in Figure 4

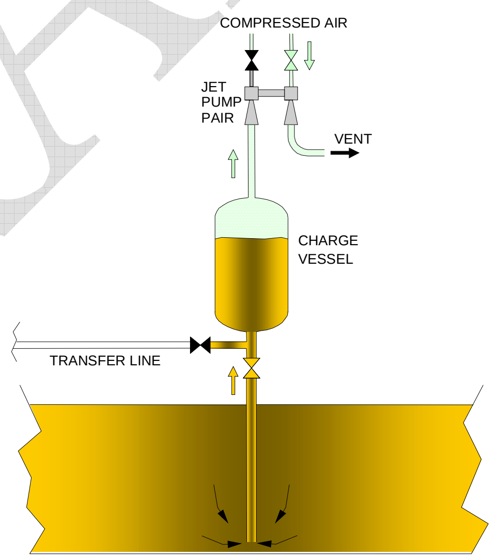


Figure 4: Suction Phase – Transfer Mode

Once the charge vessel has been filled with the liquor, the jet pumps pressurize the charge vessel, which drives the liquor along the transfer line as shown in Figure 5.

When the liquor levels have reached the bottom of the charge vessel, the drive phase is terminated and the charge vessel is vented in the same manner as in the mobilization mode (Figure 3)

This sequence can be repeated until the required amount of liquid has been transferred

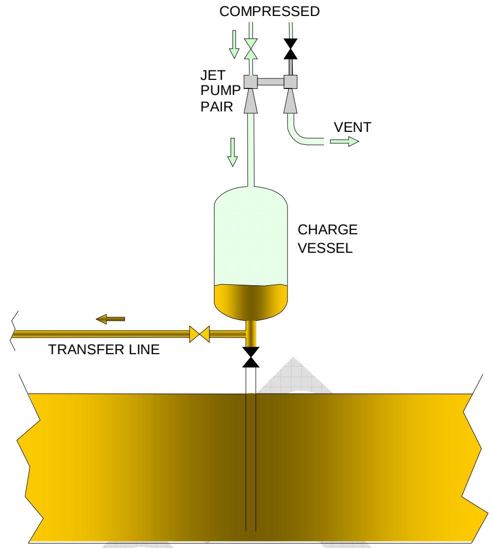


Figure 5: Drive Phase – Transfer Mode

4.4 SAMPLE MODE

The diagram below illustrates the system configuration for collecting a sample of the tank contents. Liquor is initially sucked from the tank to fill the charge vessel as in the transfer operation (Figure 4 above).

When the sample is being collected, the system is designed so that the liquid is drawn out of the charge vessel using a pump installed in the sample line to suck the sample into the collection vessel.

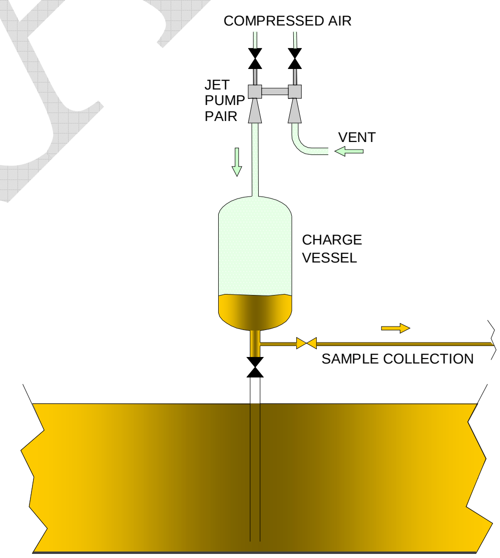


Figure 6: “Drive” Phase – Sample Mode

4.5 WALL WASH MODE

The diagram below illustrates the system configuration for wall washing. A remote directional nozzle is incorporated into the system below the charge vessel. Liquor is initially sucked from the tank to fill the charge vessel as in the transfer operation (Figure 4 above).

During the drive phase, the liquid jet emerging from the nozzle dislodges sludge adhered to the tank walls. The sludge, which then falls to the bottom of the tank, can be maintained in suspension using the mobilization mode of operation described above.

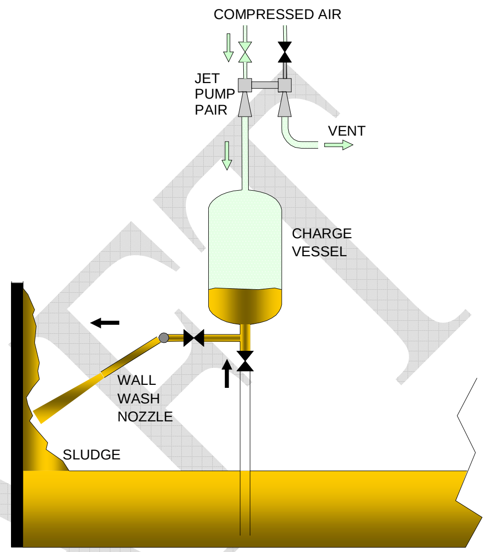


Figure 7: Drive Phase – Wall Wash Mode

5 TA 50 Mixing and Retrieval System Equipment

This section describes the major equipment items deployed at LANL. The equipment is designed in modular form and is skid mounted for ease of transport between different tank deployment locations. The AEAT equipment was designed to:

- Mix, mobilize, and retrieve waste from the sludge tank.
- Wash the tank to remove sludge material adhering to the tank walls.
- Dislodge encrusted debris from the walls of the tank
- Provide samples of the tank contents

The major modules are:

- Charge Vessel Skid (CV Skid)
- Control Hut
- In-Tank Charge Vessel / Wash Nozzle Module & Hydraulic Power Pack
- Off-gas Skid

The Charge Vessel Skid contains the principle plant items namely the charge vessel, demister, jet pump pair, barometric protection piping and main process valves.

The Control Hut contains a valve rack and the system control panel. Mounted on the valve skid are the main process valves for controlling the operation of the jet pumps (which are mounted on the Charge Vessel Skid.) and the Wash Water line. The Control panel contains the PRESCON controller and associated controls for jet pump heating. All of the utility services (compressed air, wash water and electricity) are supplied to this skid.

The In-Tank module is connected to this skid via flexible hoses. This skid also contains the connections to the sample collection and transfer lines. A hydraulic power pack is used to power the steerable nozzle on the In-tank assembly.

The Off-gas Skid is used to maintain a slight atmospheric depression on the Demister during operations.

All of the equipment described above was designed and built as part of an ongoing series of testing conducted by AEA for the DOE. Previous trials and testing of fluidic mixing equipment were conducted by AEA to determine the capacity of the technology to handle the conditions encountered in the LANL tanks. These conditions and capacities, along with the acquired test data were then used in the final design of the equipment. The purpose of the equipment was to achieve bulk retrieval of the sludge and waste in the

LANL tanks. All of the equipment was designed, built and delivered within the 2002 fiscal year.

5.1.1 Charge Vessel skid

The Charge Vessel Skid consists of:

The Charge Vessel: This is a 150 gallon nominal, ASME “U” stamped vessel that is placed under a vacuum during In-Tank Charge Vessel filling. No in-tank charge vessel in envisioned for the Generals Tanks due to the small size of the available/new risers.

The Jet Pump Pair: This is used to generate either a vacuum or a pressure within the charge vessel dependant upon the phase of the process

The Demister: This is used to eliminate airborne particulates from being carried over into the off gas system.

Process Valves: These are the automated valves providing connections to the sludge tank, discharge line and supply line dependent upon the operating regime of the mixer system.

Sample Pump: This pump is used to draw a sample of the slurry from the charge vessel.

5.1.2 Control Hut

The Control Hut contains the system control panel, the jet pump drive and suction valves and associated piping, and also the wash water valves and piping. The Control Hut is linked to the Charge Vessel Skid by flexible hoses and an electrical services umbilical cord. The connection points for Air, Water and Electricity are located on the exterior of the Control Hut.

5.1.3 Hydraulic Power Pack

The Hydraulic Power Unit provides the hydraulic fluid under pressure to the steerable nozzle. The Unit is typically placed between the In-Tank Skid and the Control Hut. Due to the small size of the risers, electrically actuated steerable nozzles will be installed on the in-tank modules for the generals tanks. Therefore, the hydraulic power packs will not be used.

5.1.4 Off-Gas Skid

The Off-gas Skid consists of:

Blower & Motor: The blower and motor assembly of the Off-gas Skid provides the suction required to draw the air out of the Demister through the HEPA filters. A separate off-gas system must be connected to the generals tanks, via the in-tank modules, to provide a slight depression in the tanks during mixing, retrieval, and sampling operations.

HEPA Filter Bank: The HEPA filters placed into the Off-gas Skid prevent contamination from entering the atmosphere if it were to be sucked out of the tank by the Jet Pump Pair.

Instrumentation: The instrumentation on the Off-gas Skid displays the differential pressure across the HEPA filters and is used to determine when the filters require replacement.

5.2 TECHNICAL APPROACH FOR TA21

5.2.1 Project Objectives

It is understood from discussions with LANL that the TA21 Generals Tanks project objectives are:

- Mixing of the waste to allow representative sampling
- Recovery of the waste from the tanks

5.2.2 General

In order to achieve the project objectives using the fluidic equipment two practical issues must be addressed:

1. The existing tanks have only one access riser available for installation of the fluidic equipment, which is located near one end of the tank(s). In order to achieve as close to uniform mixing as possible, additional access is needed to distribute mixing energy more uniformly along the tank.
2. The base of the tanks is located approximately 18 feet below grade. As the fluidic equipment operates on suction, this will potentially limit the effectiveness of the equipment if it is located at grade level.

To overcome these practical limitations the following measures are proposed:

- The installation of 2 additional 10” risers in the tanks (this operation has been proven on similar applications and can be achieved remotely by drilling from the surface)
- Excavation of some of the overburden above the tanks to allow the fluidic equipment to be located as near as possible to the tank top (a depth of 8 feet below grade will be required – see appendix A for the supporting calculation)

5.2.3 Installation of New Risers

The hot waste tanks at the Test Reactor Area at INEEL, were direct buried radioactive waste tanks buried 20 feet below grade. In order to gain direct access the tanks, a local ground water company was contracted to drill and install standard 10-inch diameter well casings.

5.2.4 Excavation of Overburden

The fluidic charge vessel skid must be located in an excavation adjacent to the tanks. During operation, the tank material will be drawn into the above ground charge vessel and discharged back into the tank or transferred to a separate “container”. The calculation determining the depth of the excavation is in appendix A.

5.2.5 Equipment Installation

The fluidic equipment at TA50 currently comprises:

- Charge Vessel Skid
- Control Skid
- Off-Gas Skid
- In-Tank Module

This equipment will be modified by adding steerable nozzles (In-tank modules), which would fit down each riser. These nozzles will be used to alternately suck in and discharge waste from the tanks into the charge vessel located on the charge vessel skid. Each nozzle will be capable of being rotated, so that the jet from the nozzle can be directed to different areas of the tank.

These In-tank modules will also incorporate upper, steerable nozzles providing an alternate means to allow liquid to be directed at the walls or base of the tank thus increasing retrieval efficiency and allowing ‘wall-washing’ to take place.

Site Input Required: Currently three in-tank modules are envisioned having one pulse tube and one steerable nozzle each to maximize mixing, wall washing and sampling efficiency. Other provisions to be considered are:

- Will an off-gas connection be required on the in-tank module heads?
- What is an acceptable means of sealing the in-tank modules to the tank top/ground/concrete slab? If the seal is not tight so that negative tank pressure produces inflow to the tank, what will be done if the off-gas system shuts down due to a power interruption, etc.

AEAT Decisions to be made:

- Should the nozzles rotate or should the entire assembly rotate?
- How many cameras are required and through which connections should they be installed?

The fluidic equipment is currently configured to operate up to two (2) In-tank modules and it is expected that at least three (3) modules will be required for the Generals Tanks which in turn means some modifications to the operating software and the addition of an ancillary valve skid as shown in Figure 8 through Figure 12.

After transportation from TA50 the modules must be set on a prepared and leveled base or set and leveled on temporary timber sleepers. After the new and existing tank risers have been installed/ made accessible, an interface plate would be installed over the risers to mate with the in-tank nozzle modules. If required, a load bearing ‘bridge’ structure can be set in place to span the tanks and prevent the load of the in-tank equipment from directly impinging upon the tanks.

Site Input Required: It is assumed that the overburden above the concrete slab will be removed prior to installation of the in-tank modules. This requires confirmation. Is the concrete slab structurally sound? That is, will it be able to support the in-tank modules or will a secondary structure (e.g. gantry) be required to support the equipment?

Once the Fluidic equipment has been set in place and the in-tank modules installed, essential hose and electrical interconnections will be made using AEA supplied hoses and cables.

Following completion of skid placement and interconnection but prior to final connection to the in-tank modules, the system will be subjected to a series of basic commissioning tests. This test is designed for two purposes:

Comment: Testing of the in-tank assembly will likely entail a single drive of clean water into the tank prior to hot operations to verify leak tightness and operability in addition to standard commissioning tests such as moving the nozzles, moving the camera etc. Is this sufficient?

- To demonstrate satisfactory integrity and operation of the AEA system prior to connection to the active tank contents.
- To act as a means of providing practical hands-on training for system operators*

*In advance of the practical training stage, operators will be provided with basic classroom training on system principles, control and operation.

Note: The In-tank equipment is normally not included in the functional cold test as it is already deployed into the active tank. Functional performance of the in-tank equipment will be demonstrated through a series of commissioning tests and a single drive phase using clean wash water prior to using the equipment on the active system.

5.3 OUTLINE OPERATIONS AT TA 21

The fluidic mobilization system is designed to recover tank waste in a controlled manner, either by mixing the entire tank contents in one campaign or mobilizing and recovering the tank contents in a number of large ‘zones’. The particular strategy employed to recover the TA21 Generals Tanks will depend upon the operational goals and tank waste characteristics. The zone recovery approach has several distinct advantages:

1) Optimized equipment size.
2) Value engineering for minimum equipment cost.
3) Reduced secondary waste generation.
4) Reduced criticality risk by recovering tank contents in zones.

Utilizing a “phased” approach does not have a detrimental effect on the overall schedule required to recover the tank. AEA Technology’s experience on tank waste retrieval projects is that recovery operations are generally limited by the rate of transfer of waste from the charge vessel to the transport container (e.g. 55 gallon drum or High Integrity Container). The fluidic system can generally mobilize and transfer waste faster than the drum or HIC’s can be set-up for filling.

Site Input Required: What is the “container” that the waste will be delivered to? This can be accomplished via the charge vessel if the container is large enough or by a separate transfer pump if more control of delivered volume is required for transfers into small containers.

The mobilization and transfer system is designed to be as versatile in operation as possible. The system can operate in a number of modes dependant upon the particular stage of the recovery operations. These modes of operation are described below.

Site input required: A mixing and retrieval strategy must be developed and incorporated into the designed. For example:

- Will there be need to transfer material between the two tanks?
- Will there be an inactive period between sampling and retrieval? If so, what must be done to secure the tank in the interim?
- Will the in-tank modules be moved from the first tank to the second or will six in-tank modules (3 for each tank) be required.

5.3.1 Initial Mobilization & Sampling

It is expected that the sludge in the tanks is settled and compacted due to the length of time it has been left unagitated. The first part of the retrieval operation is to “re-hydrate” the sludge. This will be achieved by the operation of the charge vessel and associated suction and mobilization nozzles as described in section 3. Initially, the sludge local to each in-tank nozzle will be mixed. This will create a “well” in the sludge around each nozzle, which will progressively become larger as the mixing progresses. The first phase of operation is a suction phase used to draw material up into the charge vessel. This is illustrated in Figure 8 below.

Site input required: Currently the conceptual design has no facility for removing supernatant preferentially from above the sludge layer. Is this needed? Is there any data on the liquid volume or supernatant to sludge ratio in the tank? Optimum mixing is achieved with a 2 to 1 ratio.

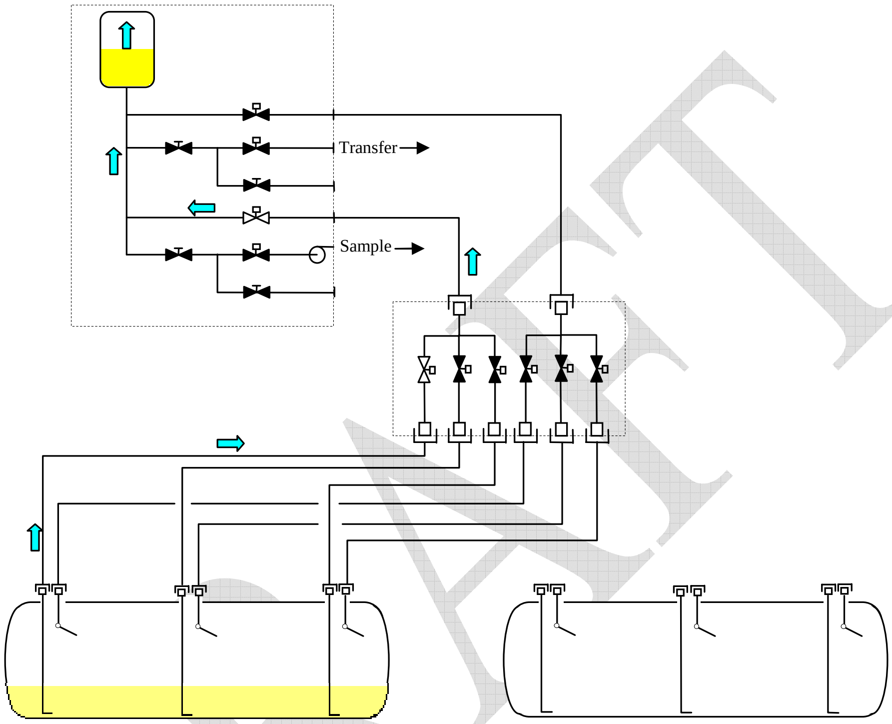


Figure 8 Suction Phase

Following the suction phase the material in the charge vessel is discharged back into the tank via one of the suction nozzles near the bottom of the tank. See Figure 9 below. Each nozzle can be rotated through 360^{o} to mix the contents around it. The jet of slurry can be directed through each of the three suction nozzles, in turn. Simultaneous operation of more than one nozzle is not possible.

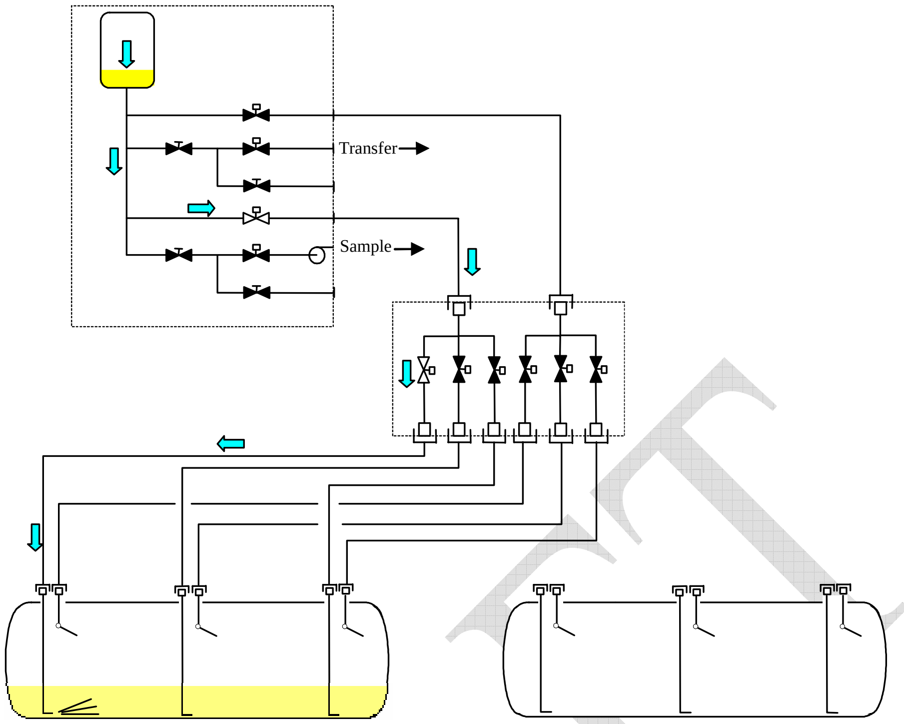


Figure 9 Suspension/Mobilization

5.3.2 Sampling

At the base of the charge vessel, there is a valve manifold that will allow a sample of the mixed waste from the tank to be collected in a controlled manner. The system controller enables the operator to switch to sample mode at any stage during the operations. At the end of the mixing phase, waste is drawn up into the charge vessel and the valving operated to collect a sample. The charge vessel is then drained back in to the tank. See Figure 10 below.

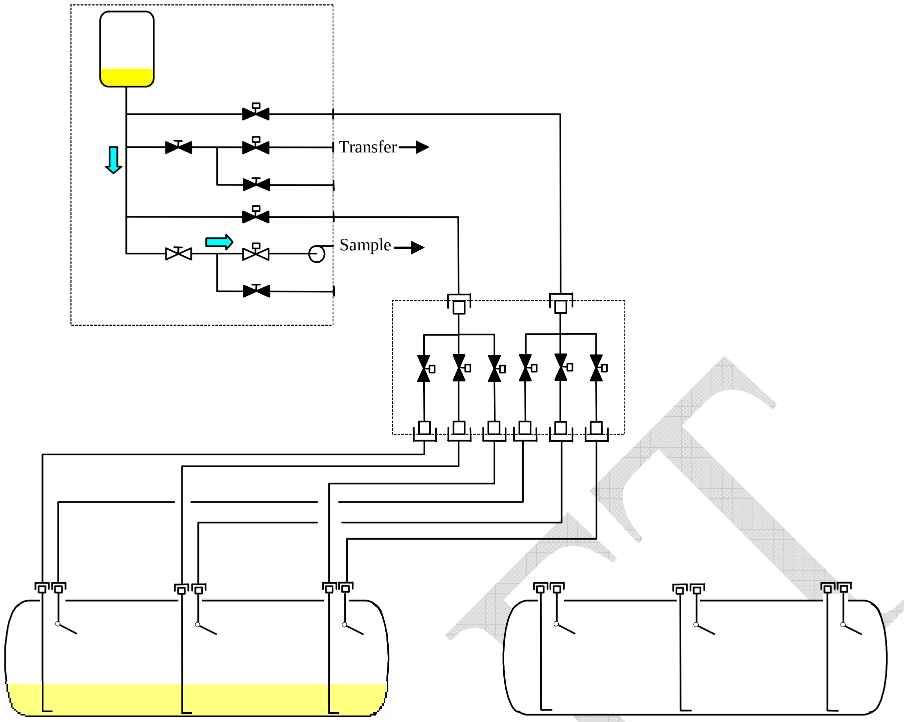


Figure 10 Sample

5.3.3 Waste Transfer

The system design allows for two modes of transfer dependant upon operational constraints and transfer strategy. Following the mixing and sampling phase described above, the waste is drawn-up into the charge vessel. If the volume of the receipt vessel for the waste is less than the volume of the charge vessel (e.g. a drum) then a mechanical metering pump can be used to transfer the waste from the charge vessel to the receipt vessel. If the receipt vessel is larger than the charge vessel (e.g. a HIC) then the charge vessel itself can be used to transfer the waste from the tank into the container. See Figure 11 below.

The decision when to transfer the slurry is normally taken when the mobilization operations have reached "steady state" whereby continued operation would not suspend any more sludge. During operations, the time taken to fill each charge vessel is monitored; the duration of the suction time provides a useful indicator of when steady state is reached.

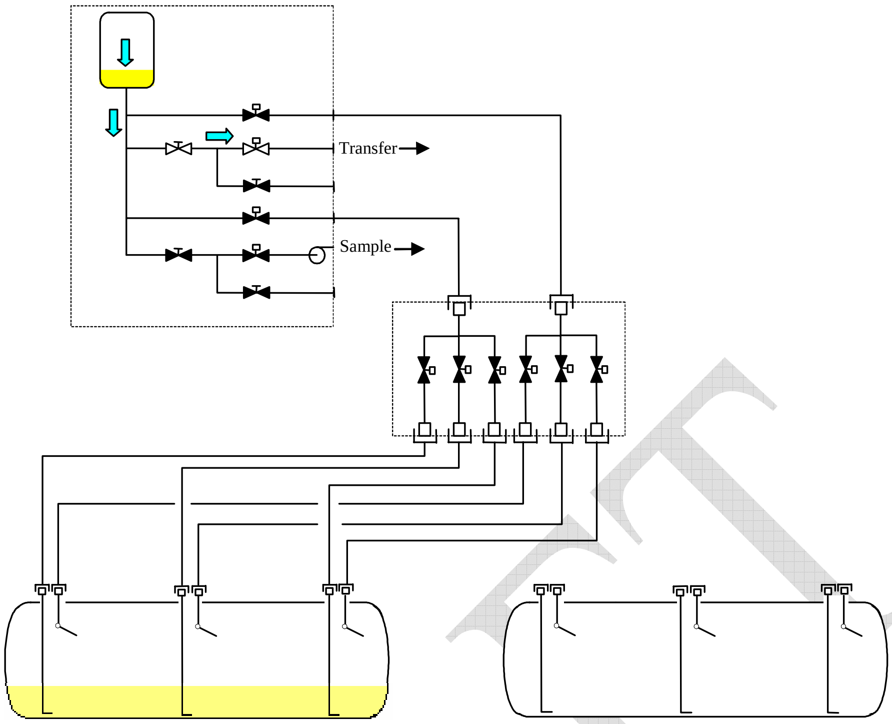


Figure 11 Transfer

5.3.4 Wall Washing and Final Heel Retrieval

After the bulk of the waste has been removed from the tank, steerable nozzles will be used to direct a jet of liquid against the walls of the tank removing any residual sludge that might be present. See Figure 12 below. The pressure of the jets can be regulated from a few PSI, where the water is pulled into the charge vessel and allowed to drain under gravity, to pressure assisted washing up to 60 PSI. The actual value will be dependent upon the waste hardness and structural integrity of the tank at the time of the recovery, however, even at higher pressure, impact on tank structure and internals is minimal.

It should be noted that in this mode of operation the system provides all the benefits of "past practice sluicing" while utilizing a fixed small volume of free water in the tank and minimizing secondary waste generation. Virtually all operations can be controlled from the control hut, which is a radiologically clean environment and can be located so as to minimize operational dose uptake for workers.

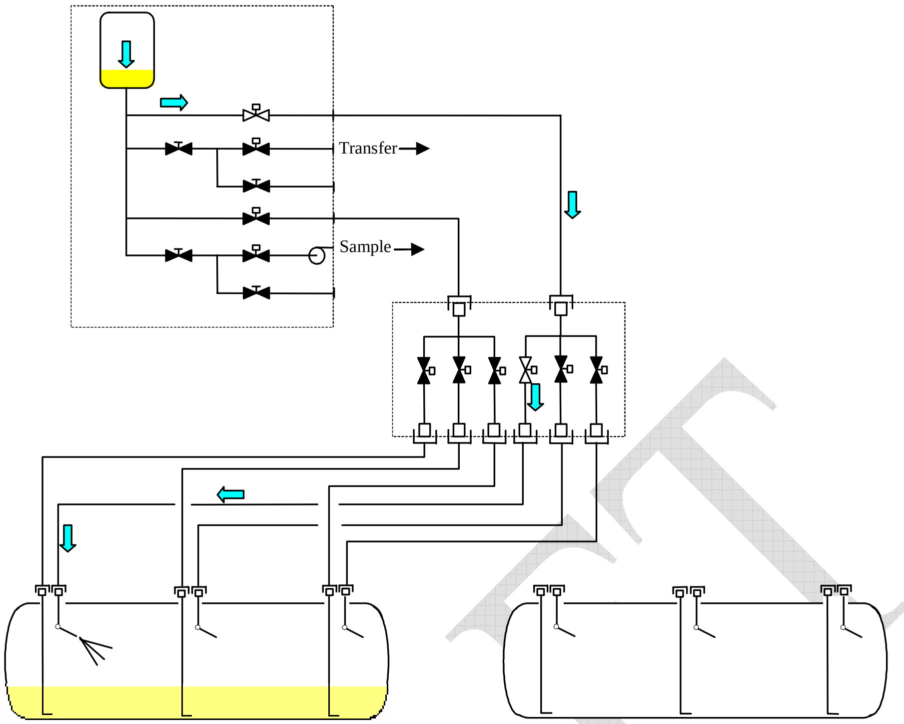


Figure 12 Wall Wash

5.4 EQUIPMENT DECOMMISSIONING AND DECONTAMINATION

Upon completion of operations, the fluidic equipment will be decommissioned and decontaminated in preparation for removal and storage or relocation to another site. Components such as the control hut will remain radiologically clean following completion of operations and can be quickly disconnected and relocated.

The charge vessel skid (which will have internal surfaces which have been in contact with the process fluid) is designed to be comprehensively flushed to drain remaining residual contamination back into the waste tank. Following flushing and draining, the process and air hose connections will be removed and capped off. The system can then be monitored prior to relocation to a storage area or another site.

In-tank equipment may be successfully flushed, drained, and externally decontaminated upon withdrawal should there be a need to re-use it or to comply with the tank closure plan. Alternatively, if the tank closure plan allows, the in-tank equipment may be lowered into the tank for disposal and stabilization (e.g. by grouting).

Site input required: Disposition will affect design. The equipment can be designed to be disconnected and dropped into the tanks prior to stabilization, if required. If the equipment is to be withdrawn from the tank and dispositioned separately, this can also be accommodated.

5.5 FLUIDIC EQUIPMENT WEIGHTS AND UTILITY REQUIREMENTS

Estimated Equipment Weights and Sizes
Estimated sizes and (conservative) weight estimates of mobile fluidic equipment modules are:

Equipment	Size (Estimate)	Weight (Estimate)
Charge Vessel Skid	9' wide x 15' long x 14' high (includes "top hat" section – removable for transport)	15,000 lbs
Control Hut	12' long x 8' wide x 7' 6" high	9,000 lbs
In – tank module	TBD	Up to 1500 lbs
Off-Gas Skid	24' long x 7' 6" wide x 15' tall (includes stack - removable for transport)	8,500 lbs

Utilities
The utility requirements are as follows:

Water

13 GPM @ 30 psig

Air

0-1000 SCFM (peak), 250 SCFM (average), 80 PSIG (min), 120 PSI (max)

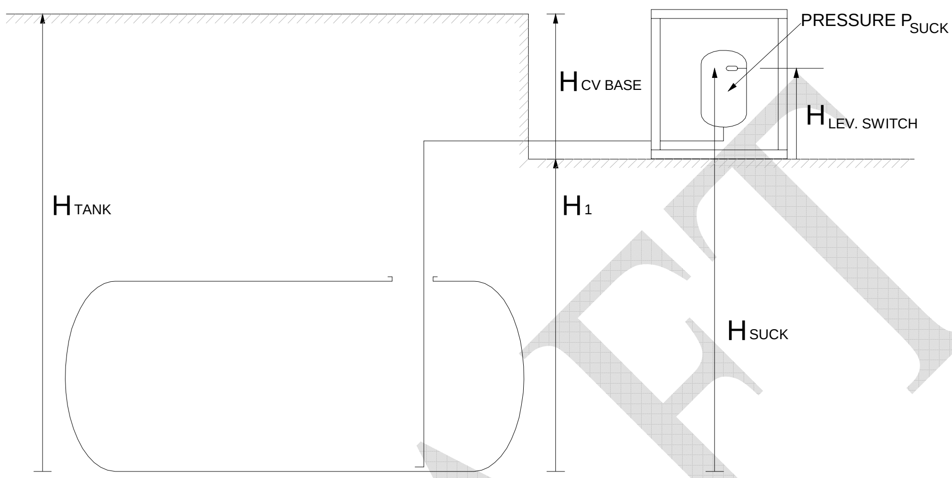
Electrical Supply

Control Hut: 60 amps@480 VAC, 3 phase
Off Gas Skid:60 amps @ 480 VAC, 3 phase
(these are connected to separate feeds)

Appendix A

Charge Vessel Skid Elevation Calculations

B1. Derivation of basic equations



Using the terminology in the figure above:

$$P_{SUCK} = -\rho g H_{SUCK} \qquad ....(1)$$

where

P_{SUCK}	=	Suction pressure in the Charge Vessel created by the Jet Pump (Barg)
ρ	=	Fluid density (kg/m^3)
g	=	Gravitational acceleration constant = 9.81 m/s^2 (=32.2 ft/sec^2) [Ref 1]
H_{SUCK}	=	Suction Height (m)

$$SG = \frac{\rho}{\rho_{WATER}} \qquad ....(2)$$

where

SG	=	Fluid specific gravity
ρ_{WATER}	=	Water density =1000 Kg/m^3 (=62.43 lb/ft^3) [Ref. 1]

$$H_{SUCK} = H_{LEV.SWITCH} + H_1 \qquad ....(3)$$

$$H_{TANK} = H_{CV.BASE} + H_1 \qquad ....(4)$$

Combining equations (1) to (4) gives:

$$H_{CV.BASE} = H_{TANK} + H_{LEV.SWITCH} + \frac{P_{SUCK}}{SG \times \rho_{WATER} \times g} \qquad ....(5)$$

B2 - Charge Vessel Pressure -PSUCK

Maximum suction from LANL Jet Pump = -0.875 Barg at sea level (-12.687 psig)

Allow some margin to be conservative, assume maximum suction = -0.85 Barg (-12.325 psig)

Standard Atmospheric pressure at sea level = P_{atmos} = 1.01325 Bara (=14.696 psia) [Ref 1]

Hence absolute suction generated by Jet Pump = 1.01325-0.85 = 0.16325 Bara (2.367 psia)

Altitude of LANL ≅ 7000 ft, from Ref 1:

Altitude (ft)	Atmospheric Pressure (psia)
0	14.696
4000	12.692
5000	12.225
7000	11.341

Patmos = 11.341 psia = 0.7819 Bara

Therefore, gauge suction pressure achievable by Jet Pumps = -0.7819 + 0.1633 = -.6187 Barg = -8.973 psig

Hence $\underline{P_{SUCK} = -0.6187 \text{ Barg}}$

B3 - Charge Vessel Level Switch Height $H_{LEV.SWITCH}$

From Ref 2 and 3, $\underline{H_{LEV.SWITCH} = 73.25'' = 1.861m}$

B4 – General's Tanks Calculations

From 4, H_{TANK} =100.25'-81.00' = 19' = 5.791m

Example calculation for SG=1.0:

From equation (5):

$$H_{CV.BASE} = H_{TANK} + H_{LEV.SWITCH} + \frac{P_{SUCK}}{SG \times \rho_{WATER} \times g}$$

$$H_{CV.BASE} = 5.791 + 1.861 + \frac{-.6187 \times 10^5}{1.0 \times 1000 \times 9.81} m = 1.345m = 4.413\,ft$$

The results of calculations at other specific gravities are tabulated below:

SG	$H_{CV\ BASE}$ (FT)
1.0	4.413
1.1	6.294
1.2	7.862
1.3	9.188