

COMPLETING HLW VITRIFICATION AT THE WVDP; THE APPROACH TO FINAL RETRIEVAL, FLUSHING, AND CHARACTERIZATION

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ABSTRACT

The processing of high-level waste (HLW) at the West Valley Demonstration Project (WVDP) began in 1988 with the start up of the Integrated Radioactive Waste Treatment System to remove soluble salts from the stored HLW. Twelve years later, HLW removal from the storage tanks is now in the final stages and the vitrification campaign is also nearly complete. To establish the conditions needed to conclude HLW retrieval and processing, a shift in priorities has been required. The focus has changed from the efficient bulk removal of HLW from the tanks and the production of qualified HLW glass, to selecting efficient residue-removal techniques, managing the water needed for transfers, establishing cleanliness criteria, and performing radiological characterizations to these criteria. This operational shift establishes the conditions needed for an efficient and orderly shutdown of the HLW Vitrification Facility (VF) that has fulfilled its mission.

HLW at the WVDP is defined as characteristically hazardous under The Resource Conservation and Recovery Act (RCRA) and therefore is regulated as mixed waste. The RCRA component of mixed waste characterization or the tank systems clean up performance standards is being separately addressed outside this paper.

BACKGROUND AND HISTORICAL APPROACH TO HLW RETRIEVAL AND PROCESSING

The West Valley Demonstration Project (the Project) is located on an approximately 200-acre site about 30 miles south of Buffalo, New York. The site is owned by the state of New York, managed by the U. S. Department of Energy (DOE), and operated by West Valley Nuclear Services Company.

The Project is at the site of a former commercial nuclear fuel reprocessing plant originally operated by Nuclear Fuel Services Company, Inc. The facility was completed and first operated in 1966. In 1972, seven years after operations began, production ceased. During the operating period, the plant generated approximately 600,000 gallons (2,270,000 liters) of high-level waste (HLW). In 1980, with the passage of the West Valley Demonstration Project Act by the United States Congress, DOE was charged, among other things, with the responsibility to implement a program demonstrating the feasibility of converting liquid high-level radioactive waste into a solidified form acceptable for transportation and eventual disposal.

HLW at the WVDP is defined as characteristically hazardous under The Resource Conservation and Recovery Act (RCRA) and therefore is regulated as mixed waste. Although this paper does not address the RCRA component of mixed waste characterization or the tank systems clean up performance standards, it is important to note that the RCRA aspects are being addressed separately to comply with the regulatory standards.

In 1990, the Environmental Protection Agency issued requirements for treatment of HLW by vitrification under the Land Disposal Restrictions program. Vitrification as a borosilicate glass was selected as the HLW solidification technology as a result of a recommendation by the National Academy of Sciences. (1)

The WVDP has minimized the volume of waste that results from the removal and vitrification of HLW from the Waste Tank Farm (WTF). Two tanks contained HLW at the start of the Project. Approximately 600,000 gallons (2,270,000 liters) of basic plutonium-uranium extraction (PUREX) waste consisting of a precipitated sludge and supernatant were stored in Tank 8D-2, and approximately 15,000 gallons (57,000 liters) of thorium extraction (THOREX) waste were stored in Tank 8D-4. In order to reduce the amount of HLW glass that would result from the direct vitrification of these wastes, soluble salts (primarily sodium nitrate and sulfate) were washed from the material. The wash process was conducted using the Supernatant Treatment System (STS) which was installed in and adjacent to Tank 8D-1. The STS used 1700-liter zeolite columns to remove soluble Cs-137 and with the later implementation of titanium-coated, zeolite-soluble plutonium and strontium, retained the soluble Cs-137 for solidification as HLW. The decontaminated liquid from the process was concentrated by evaporation and then solidified in cement. This waste pretreatment generated approximately 20,000, 270-liter square drums of low-level waste (LLW) cement and reduced the number of 3m-long, 61-cm-diameter HLW canisters by a factor of ten. It also resulted in 2,600 cubic feet (74,000 liters) of Cs-137-laden zeolite which was stored within Tank 8D-1 prior to the vitrification campaign. (2)

To simplify the vitrification operations, HLW constituents (washed PUREX sludge, THOREX, and zeolite) were consolidated in 8D-2 prior to the start of vitrification. Greater than 99 percent of the THOREX from Tank 8D-4, and about 90 percent of the zeolite from 8D-1 were added to the PUREX sludge in 8D-2 prior to vitrification startup. This combination represented approximately 95% of the HLW activity and greater than 99% of the long-lived actinides stored at the site. Most of the radioactivity at this stage was in a solid phase consisting of a precipitated PUREX and THOREX sludge mixed with zeolite. During the vitrification campaign additional amounts of zeolite have been moved from Tank 8D-1 to Tank 8D-2.

The process of moving this solid material from one tank to another is accomplished by suspending the sludge with mobilization pumps and transferring the resulting slurry with multistage pumps that draw suction near the bottom

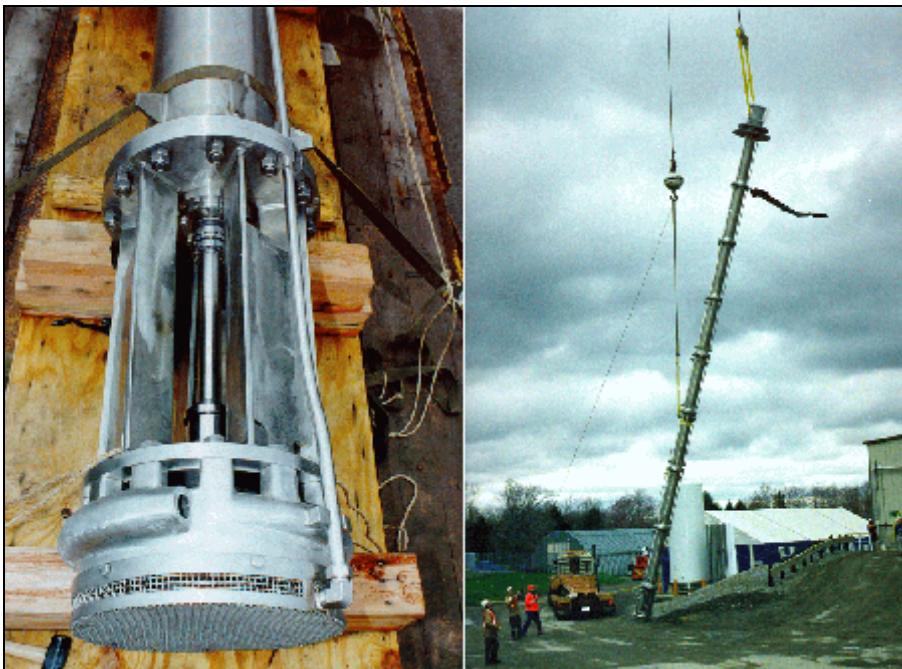


Fig. 1. Mobilization Pump

of the tank. The mobilization pumps (Figure 1) have 150-horsepower motors housed on top 50-ft (15.3-meter) segmented stainless steel columns that contain the motor to pump drive shafts. The pumps discharge 600 gallons (2,300 liters) per minute through two tangential nozzles, and can be rotated up to 3 rpm through 360 degrees. Five or six of these pumps have been installed in the waste tanks to mobilize sludge or zeolite. The HLW vitrification process, as illustrated in Figure 2, began operations in 1996 and has been operating for approximately 4 ½ years. The process consists of periodic consolidations of additional solids from Tanks 8D-1 (zeolite) or 8D-4 (recycle from the vitrification process) into Tank

8D-2. As illustrated, the transfers to the vitrification process take place principally from 8D-2 to the concentrator feed make-up tank (CFMT). The CFMT also receives recycle streams from the canister decontamination and off-gas processing systems. Qualification of feed for the slurry-fed ceramic melter (SFCM) takes place in that tank through a series of sampling, concentration, and chemical shimming steps. Once acceptable feed is prepared, the contents are moved to the melter feed hold tank (MFHT) and fed to the SFCM.

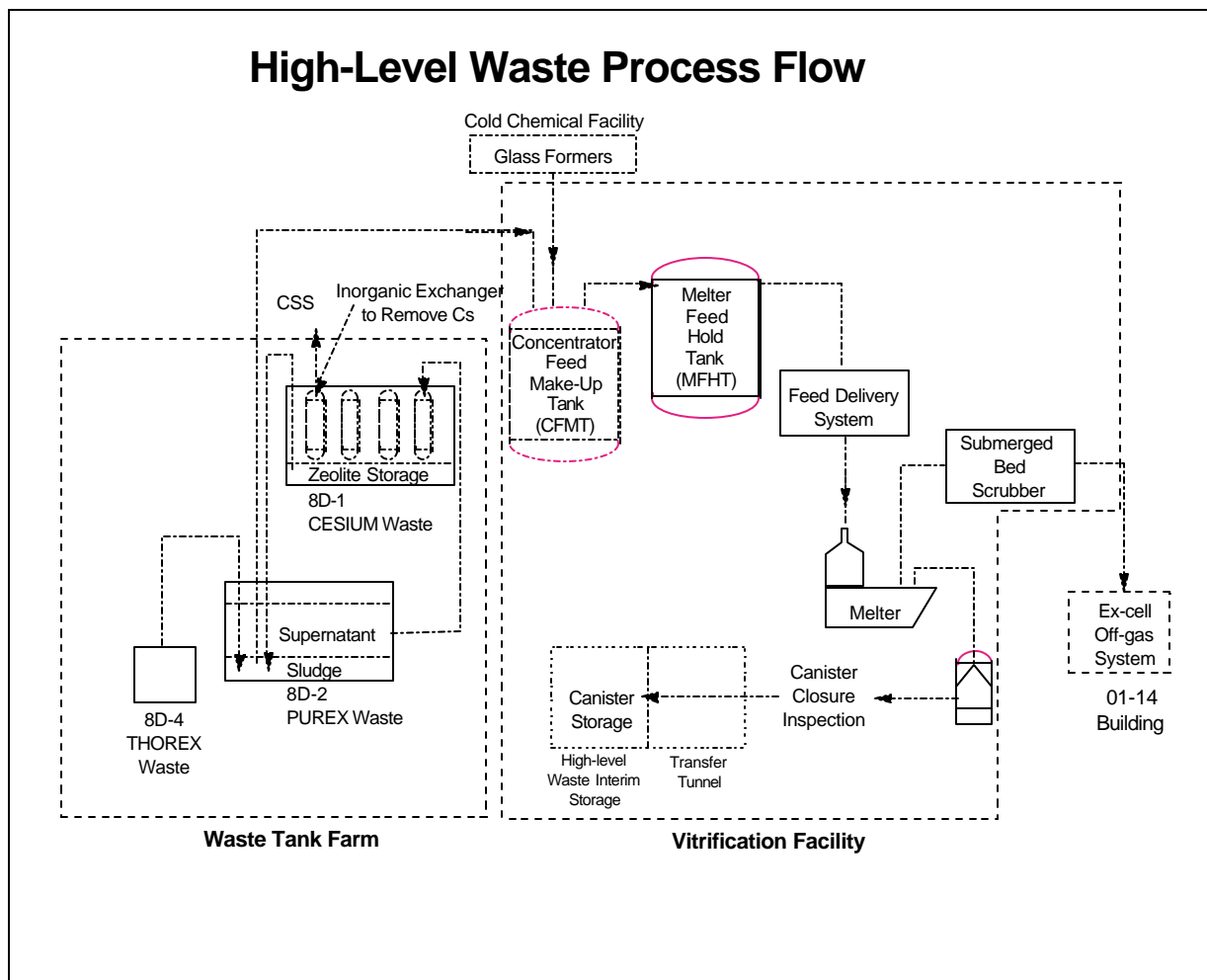


Fig. 2. HLW Process Flow

At the beginning of CY2001, retrieval of HLW residues from Tank 8D-2 is ongoing. The VF is completing the processing of Batch 72. Current operating plans would make Batch 75 the final HLW batch vitrified.

In order to track progress during vitrification operations, several metrics were chosen: the number of canisters produced, the waste loading in the HLW glass, the amount of Cs-137 and Sr-90 processed, and the canister fill height. The objective of effective and efficient production performance was to maximize these parameters individually and over time. During the early stage, the waste retrieval process was very efficient and these measures drove efficient vitrification operations very effectively. One 5,000-gallon (19,000-liter) transfer from 8D-2 to the vitrification process was sufficient to produce at least three HLW canisters at their maximum waste loading, and melter feed batches could be prepared fast enough so that melter idling was not necessary. As the removal of the contents of 8D-2 moved from bulk removal to heel and residue retrieval, the number of transfers

and associated time required to generate a melter feed batch has climbed steadily (Figure 3) and it has become apparent that these measures no longer provide good indicators for completion. In order move to completion, the final ending criteria for Tanks 8D-1 and 8D-2 needed to be established. This was originally assumed to be some final radioactive material retrieval goal of greater than 99% and possibly as high as 99.9% as the Project was developed in the 1980s. A more recent assessment of Project and health and safety risks has resulted in the

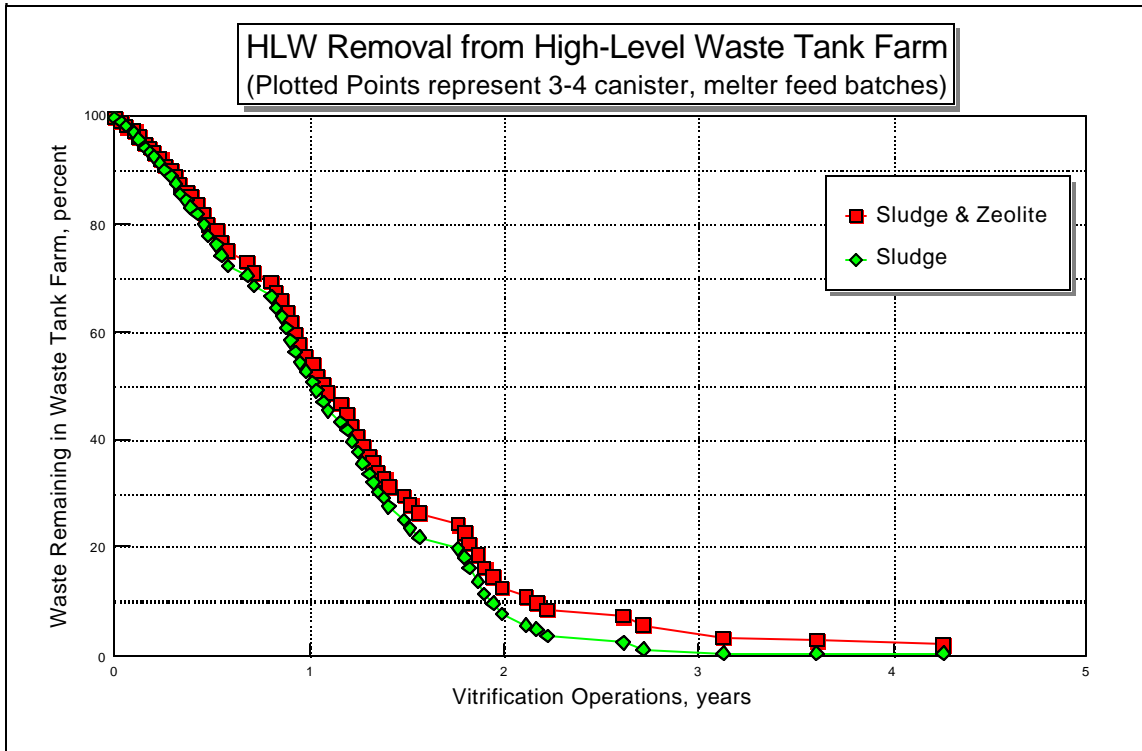


Fig. 3. HLW Retrieval as a Function of Vitrification Operating Time

establishment of a HLW vitrification completion criteria based on the long-term performance of stabilized residual waste rather than the early, simplistic, >99% waste removal criteria.

CRITERIA FOR COMPLETION

The principle criterion for completion of HLW operations is to have sufficiently removed HLW from the HLW tanks to ensure that the stabilized residual waste can be managed in accordance with the federal and state requirements. A very important secondary criterion is to ensure that the entire HLW processing system is shutdown in an engineered fashion and equipment failures do not preclude the well-organized shutdown process. The HLW vitrification system at the WVDP is designed to be closely coupled to the primary waste tank in the WTF. Retrieval from HLW tanks without the vitrification process being operational is not possible. As a result, HLW and operational criteria need to be considered in a coordinated manner. Based on nearing the completion of HLW retrieval, the Project is focusing intently on how to finish HLW vitrification operations.

Because the treatment approach required for HLW is vitrification, shutdown of the VF would require that there is no more vitrifiable HLW remaining in the tanks or the VF itself. Historically, this is problematic because the definition of HLW under United States Federal Regulations is based on the source of the waste not the concentration of the individual radionuclides. To resolve that issue, the Nuclear Regulatory Commission (NRC)

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and DOE have settled on the waste incidental to reprocessing (WIR) criterion as the basis for managing waste as other than HLW. The WIR criteria were documented in a letter from R. Bernero, NRC to J. Lytle, DOE, dated March 2, 1993. (3) NRC guidance states that in order to consider a waste stream, derived from HLW, to be *other than HLW*, three criteria are to be satisfied:

1. The waste has been processed (or will be further processed) to remove key radionuclides to the maximum extent that is technically and economically practical.
2. The waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW as set out in 10 CFR Part 61.
3. The waste will be managed pursuant to the Atomic Energy Act, so that safety requirements comparable to the performance objectives set out in 10 CFR Part 61 are satisfied.

DOE refined the criteria in DOE Order 435.1, adding a transuranic (TRU) waste management option in addition to the LLW criterion. Two possible outcomes exist for successful application of the criterion, either the waste is suitable for management as LLW or it is suitable for management as TRU waste.

The WVDP intends to apply the LLW option for Tanks 8D-1 and 8D-2. This preserves all the possible closure options identified in the WVDP Draft Environmental Impact Statement (DEIS). (4) The TRU option is not appropriate at the West Valley site for any component that is difficult to remove (e.g., Tanks 8D-1 and 8D-2), as TRU waste is not considered appropriate for near-surface disposal and would be incompatible with the DEIS close-in-place alternative. As such, the WVDP intends to apply the LLW criteria noted above.

In order to complete HLW processing at the site these incidental waste criteria are being applied to the components that have been processed or been wetted by HLW. This includes Tank 8D-4, the zeolite ion-exchange system, the WTF transfer pumps and piping, vitrification process vessels, and several original NFS transfer pipelines. As it is feasible to remove these additional systems for disposal, it is expected that they can be managed as either LLW or TRU based on DOE Order 435.1. In either case, the technical and economic practicality test needs to be successfully satisfied. Flushing plans for this equipment are designed to thoroughly clean the equipment and lines, but final classification will not be completed as part of the flushing campaigns.

The "engineered shutdown" approaches are being applied to the final completion process: 1.) consider the chances of melter or major equipment failure, 2.) maintain qualification of vitrified HLW form, and 3.) do not produce significant additional HLW glass.

Since vitrification is the mandated process method for treating and stabilizing mixed HLW, a melter failure would be a significant set back. The melter suffers the least amount of thermally induced aging while in the production mode. Melter replacement at the WVDP would be difficult and could take a minimum of one to two years, in addition to the expenditure of significant resources. The first operational criteria is addressed by not prolonging melter operations longer than needed.

The second and third operational criteria are addressed by managing the process chemistry that provides constraints on the selection of flushing reagents. Any HLW glass produced is required to comply with the DOE Office of Environmental Management (DOE-EM) Waste Acceptance Product Specification (WAPS). Qualification is maintained by the ability to adjust composition by adding nonradioactive raw materials to the waste prior to feeding the waste to the melter. This adjusts for variations in the constituents transferred from the HLW

tanks. It does not allow for significant new chemical species without an extensive qualification program. Minimization of the number of HLW canisters has been a goal from the outset of the Project. Adding a significant amount of a qualified chemical (for example sodium hydroxide) would increase the amount of HLW glass and would violate the third criteria.

WIR Status of Tanks 8D-1 and 8D-2

The WIR assessments for the HLW tanks are in progress. This section describes the assessments completed to date and provides the baseline data supporting the facility shutdown strategy discussed later in this paper.

Cost benefit analyses have been completed to evaluate when additional waste removal from the WTF would no longer be economically and technically practical. These analyses show that waste removal would no longer be practical, from a risk reduction perspective, at a point before LLW Class C criteria are met.

The LLW Class C concentration limits WIR criterion has generally been considered the most difficult and limiting for the HLW tanks. Directly meeting LLW Class C is the current approach guiding retrieval of HLW residues though, as final retrieval proceeds, this assumption may be revisited. Using NRC guidance (5) on concentration averaging, the tanks and residues have been treated separately. Any mobile residues will be mixed with, and averaged over, the mass of the stabilization material. Any residual wastes fixed to the tank surfaces would be averaged over the mass of the tank structures themselves. Table I estimates the additional residue removal required to meet the LLW Class C goal based on the September 2000 inventory estimate. Further analysis, as illustrated in Table II, demonstrates that the predominate contributor to meeting Class C concentrations are the alpha-emitting TRU nuclides.

Table I. Estimated Tank 8D-1 and 8D-2 Residual Wastes as of September 30, 2000

Tank	Cs-137 (kci)	Sr-90 (kci)	aTRU (ci)	Solids (m ³)	Potential, Additional Required Removal % to Class C ^(note 1)
8D-1 Mobile	165	6	3.2	3	0% ^(note 2)
8D-2 Mobile	30	1.5	20	0.5	0%
8D-1 Fixed	30	1.7	24	N/A	0%
8D-2 Fixed	50	17	200	N/A	50 - 90% ^(note 3)

Note 1. Class C removal estimates based on alpha-TRU curies that would govern. Assumes grout addition to stabilize mobile residual waste.

Note 2. Based on expected performance of recent additional transfers of material from 8D-1 to 8D-2. Uncertainties to be resolved by additional characterization might require 2 additional transfers to reach Class C limits.

Note 3. Ranges dependent on improved characterization and selected approach to concentration averaging.

Table II. Class C Classification Isotopes that Impact WIR Determination for Tanks 8D-1 and 8D-2, from Tables in 10 CFR Part 61.55

Radionuclide	Class C Concentration Limits	Relative Contribution to Class C ^(Note 1)
From 10 CFR 61.55, Table 1		
C-14	8 Ci/m ³	0.0001%
Tc-99	3 Ci/m ³	0.05%
I-129	0.08 Ci/m ³	0.0038%
Alpha-emitting TRU w/1/2 life >5yrs (yields a list of the isotopes of Np, Pu, Am, Cm)	100 nanoCi/gm	97%
Pu-241	3,500 nanoCi/gm	2.6%
Cm-242	20,000 nanoCi/gm	0.0025%
From 10 CFR 61.55, Table 2		
Cs-137	4,600 Ci/m ³	2.7%
Sr-90	7,000 Ci/m ³	0.14%

Note 1. Based on the efficiency of retrieval processes, and original and measured isotopic ratios.

Based on the analysis supporting the Draft Environmental Impact Statement (DEIS) for site closure, the third criterion to meet the performance objectives will be satisfied if the LLW Class C concentrations are met. Table III shows that the isotopes that would be the predominate contributors to the performance of HLW tanks if they were to be closed in place. In general, the 25 mrem off-site dose objectives are met with a 3% residue.

WIR Status of Process Systems and the VF

A final WIR evaluation has not yet started for the process systems and the VF. We are currently assuming that the WIR criteria can be satisfied by the technically and economically practical steps undertaken to remove HLW residues from those systems and components. A flushing process has been developed, based on process constraints, that is judged to maximize residue retrieval within those constraints. These process constraints are: 1) process flush paths to move contaminants toward the vitrification melter, 2) restrict reagents to those proven to be compatible with the vitrification process, 3) take no destructive actions to access interior surfaces, and 4) take no actions that result in a substantial number of additional canisters of glass. Flush plans are targeted at meeting Class C requirements, but long periods of process assessment and reflushing are not part of the current strategy as most of the components could be removed if required. The effectiveness of the flushing will be monitored using samples at available sample locations, radiological dose rate changes, and visual inspection. No effort will be made during the flushing process to arrive at a final waste characterization. Data collection to establish a long-term management approach as LLW or TRU will be planned and accomplished after melter shutdown. Assessment using a WIR procedure may identify some nonstandard HLW.

Table III. Isotopes that have Been Predominant Dose Contributors in Various Performance Assessment (PA) Scenarios (Generally when Calculated w/~3% Heels)^(Note 1)

Radionuclide	Tank 8D-1 and 8D-2 Curie Value in Closure DEIS Performance Assessment	Approximate Curies @ Class C
C-14	4	0.005
Sr-90	200,000	10,000
Tc-99	50	1
Np-237	0.7	0.05
Pu-239	70	5
Pu-240	40	1
Am-241	2,000	75

Note 1. Off-site and intruder calculations have shown acceptable doses with improved closure design, heels of ~ 3%, and a further reduction below 3% for Tc-99 by a factor of 40. Erosion scenarios have not yet been finalized and are expected to be governed by Pu isotopes.

HOW TO END HLW PROCESSING

The retrieval processes for Tank 8D-1 and 8D-2 residues were developed based on the 10 CFR 61 criteria to optimize the HLW retrieval and processing. Several key points were considered, including:

1. The majority of the remaining waste in Tank 8D-1 is zeolite.
2. The principle isotope associated with zeolite in Tank 8D-1 is Cs-137.
3. Class C appears to be the limiting criteria for the HLW tanks.
4. Cs-137 does not limit meeting the Class C criteria or closure performance.
5. Zeolite is the most difficult residual to retrieve.

Based on these observations, efficiently meeting the WIR criteria is possible by focusing on retrieval of the alpha-emitting TRU isotopes. Additional retrieval of Cs-137-laden zeolite will also be accomplished during the flushing of the vitrification and transfer systems. This strategy enables shifting from removing trace amounts of HLW to process system flushing as soon as a Class C criteria could be met within the HLW tanks.

Final Phase Retrieval and Flushing

The steps to final retrieval flushing and vitrification have followed some specific guiding principles. Remaining materials should be flushed toward the VF. The final retrieval steps should proceed from the “outside in” by not removing more material from equipment than is necessary to avoid duplication of effort. Clean material that must be dispositioned in glass should not be introduced until the later stages of the process. This means that salts and insoluble solids are not appropriate flush material until the end stages of the process. Lastly, techniques that are destructive to the equipment are to be avoided to ensure that additional operational actions are possible at a later date.

The steps are shown in Table IV which outlines the general flushing sequence and also the specific processes within a component or system.

Table IV. Outline of Final Flushing and Retrieval Activities

Retrieval/Flush Sequence	Activity Outline
Tank 8D-2	Take Tank 8D-2 mobile material to Class C levels for the first time <ul style="list-style-type: none"> • Mobilization pumps fluidize the tank • Convey slurry to vitrification process • Inspect Tank 8D-2 for cleanliness levels
Tank 8D-1	Take Tank 8D-1 to Class C levels <ul style="list-style-type: none"> • Mobilization pumps fluidize the tank • Convey slurry to Tank 8D-2 • Process excess water in parallel • Inspect Tank 8D-1 for cleanliness levels
Supernatant Treatment	<ul style="list-style-type: none"> • Flush the STS to retrieve TRU material using nitric acid and water • Flush solution conveyed to Tank 8D-2
Tank 8D-2	Take Tank 8D-2 to Class C levels for the final time <ul style="list-style-type: none"> • Spray wash the tank internals • Mobilization pumps fluidize the tank • Convey slurry to vitrification process • Inspect Tank 8D-2 for cleanliness levels
Vitrification to Tank 8D-4 Header	Flush the vitrification waste header to Tank 8D-4 with dilute nitric acid <ul style="list-style-type: none"> • Discontinue use of the waste header
THOREX Tank 8D-4	Add additional acid to Tank 8D-4 and recirculate the tank contents
Waste Tank Farm to VF Piping & Equipment	Flush the HLW transfer lines <ul style="list-style-type: none"> • Flush from Tank 8D-4 to the vitrification process
Vitrification Facility	Final flush of the vitrification process as illustrated in Figure 4 <ul style="list-style-type: none"> • This flush results in the shutdown of the vitrification melter (Note 1)

Note 1: The vessels referred to by acronyms in Figures 4 and 6 are the: Concentrator Feed Make-up Tank (CFMT), Melter Feed Hold Tank (MFHT), Slurry-Fed Ceramic Melter (SFCM), Submerged Bed Scrubber (SBS), and High-Efficiency Mist Eliminator (HEME). The functions of these vessels in the WVDP vitrification process are described in Reference 6.

Retrieval and Flushing Alternatives Considered

Alternatives exist to the approach outlined in Table IV, both in terms of sequencing and chosen techniques. The alternatives outlined are believed to offer high performance with manageable programmatic and safety risks. The following discussion illustrates the principle choices and considerations that have lead to the selected approaches. There are many other intangibles (such as local conditions, expertise, and experience) that have also influenced the process selected.

Retrieving Residuals from Tanks

Early assessments of the HLW at the WVDP indicated that the solids in the PUREX waste were a fine particulate, generally <100 microns. The material was easy to suspend and transfer. Scale-model testing confirmed assumptions that long-shafted mixer pumps could suspend and fluidize the solids. Testing showed that baffling in the bottoms of the tanks did not significantly affect the mobilization process. Similar testing indicated that similar behavior should be expected for zeolite solids. As such, the Project started waste mobilization and retrieval using 150-horsepower (112-kilowatt) mobilization pumps to fluidize Tanks 8D-1 and 8D-2 for retrieval. The Project continues to use the same technique, but with many refinements. The refinements have proven to be more efficient than changing to another fundamentally different technique.

Other techniques have been considered and to some extent deployed. Riser-mounted robotics with limited mobility and tethered robotics have also been evaluated for both mobilization and characterization tasks. Due to the number of obstructions in the tanks, tethered robotics have not been developed for use. Riser-mounted arms and positioning systems have been developed that provide access to a 10-foot- to 15-foot-diameter (3- to 5-meter) column within the tank. This capability has been used extensively for characterizing and locating waste residues in the tanks and, to a more limited degree, to mobilize residues for retrieval. The riser-mounted positioning system is expected to provide the capability to wash residues from the tanks' internal surfaces.

Chemical methods of mobilization have been considered and developed. Oxalic acid or mixed organic acids have the best combination of capabilities. The Project has not planned to use these principally due to concerns with tank integrity.

In order to address the fixed-waste component in Tank 8D-2, some additional removal is required.

Flushing of Process Systems

The fundamental strategy for the final cleaning of the HLW processing systems involves flushing the equipment and piping in ways that allow the flushate to be fed to the vitrification melter. This limits the reagents considered principally to nitric acid or water since they are fundamentally compatible with the vitrification process and would not increase the amount of waste to be processed by adding additional salts. It also requires that the waste is generally flushed toward the vitrification system and mandated addressing those components furthest away from the melter first and working toward the melter feed tanks as shown in Figure 4.

The melter feed preparation tanks will probably need attention beyond just flushing. The tanks are agitated and as a result of splashing the tank head space has residues that will require some special techniques to clean them. Figure 5 shows a pump and associated residue around the flange at the top of the tank. Expectations are that the equipment shown in Figure 6 will require some specific flushing due to accumulations of HLW residue. The tooling selected for cleaning the locations that are not cleared as a result of normal process activities includes high-pressure spray-balls, high-pressure spray-wands, and ultrasonic transducers. Aggressive reagents were not chosen due to incompatibility and their potential to destroy equipment. "Overfilling" the tanks was dismissed due to the number of hardware changes needed to implement an overflow.

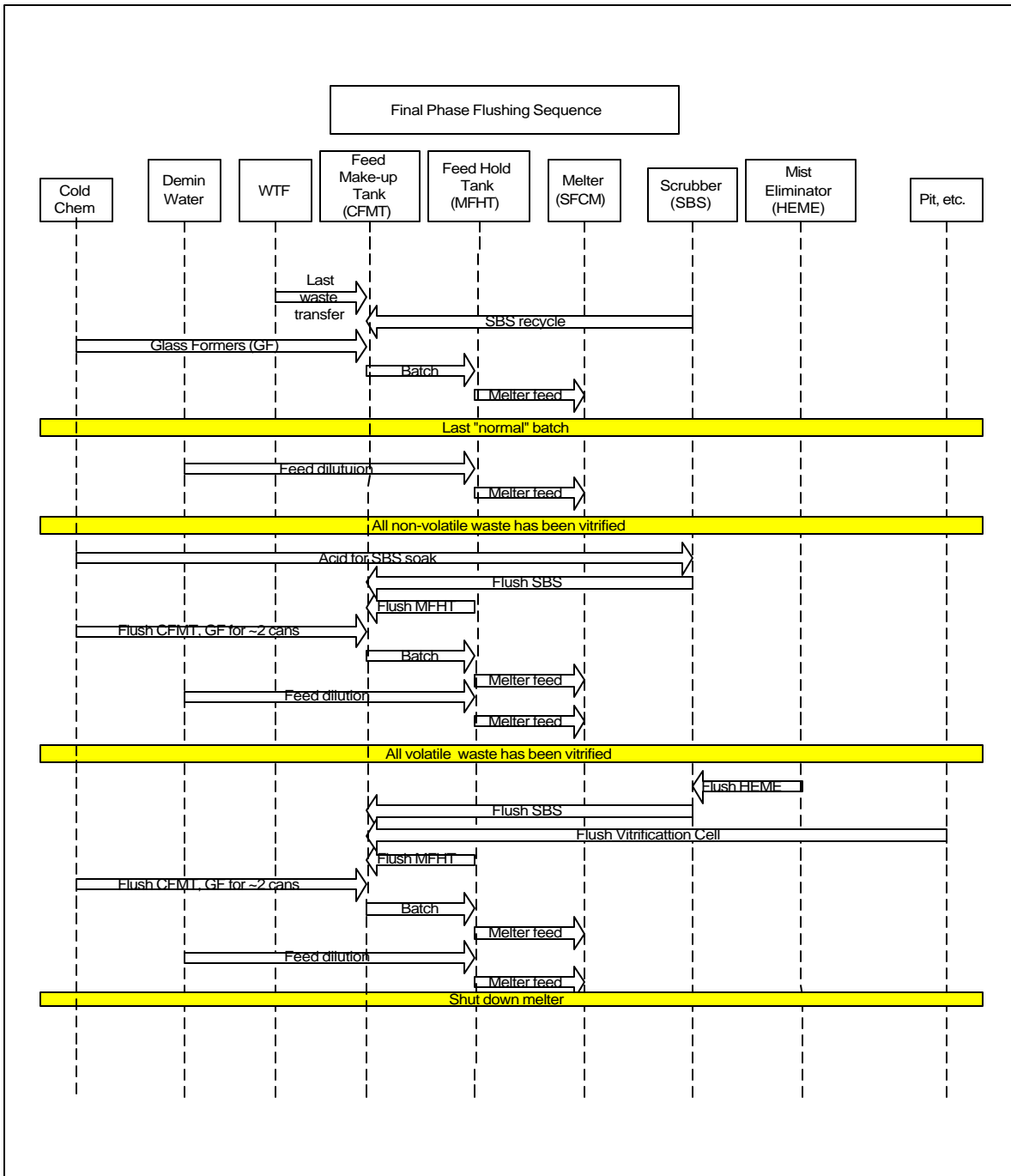


Fig. 4. Final Stage Flushing of the Vitrification Facility

MEASURING PROGRESS

An important element of the completion process is monitoring of progress. The monitoring process has several objectives, it provides:

- Confirmation that target end states have been achieved.

- Information about equipment performance.
- Information on where additional cleaning efforts need to be directed.

The parameters of interest are: the location of residues, the volume and mass of residues, and radiological quantification of the residues by isotope. No one measurement technique can quantify all three and, in the case of radiological information, multiple techniques are needed to provide isotopic information. Furthermore, many of the techniques required to directly measure specific isotopes are very intrusive and can be both time consuming and very difficult to accomplish. However, inferences from other more readily measured parameters often provide information about the other more difficult isotopes or parameters. The process of identifying the information that needs to be directly collected must have a sound basis in terms of objectives and be systematic in its development and application. The preparation of Data Quality Objectives and associated Data Acquisition Plans provides the mechanism to thoughtfully and systematically identify what data needs to be collected, why it needs to be collected, how direct measurement will be used, and how inference from process knowledge will be used to extrapolate direct measurements to more difficult-to-measure parameters.

The quantification process for residues has been divided by component. The basis for the division is essentially the same as discussed for completion criteria. The more difficult-to- remove components will need to be characterized to the extent needed to qualify them for in-place disposal if that action were to be selected. In other words, enough information needs to be collected and qualified to conclude that the component is LLW and evaluate its long-term risk significance if left in place. The more easily removed components do not need all of this information to support the shutdown of HLW processing. Rather, they need to be evaluated to ensure that the most waste technically and economically practical has been retrieved from



Fig. 5. Concentrator Air Displacement Slurry Pump with HLW Residue

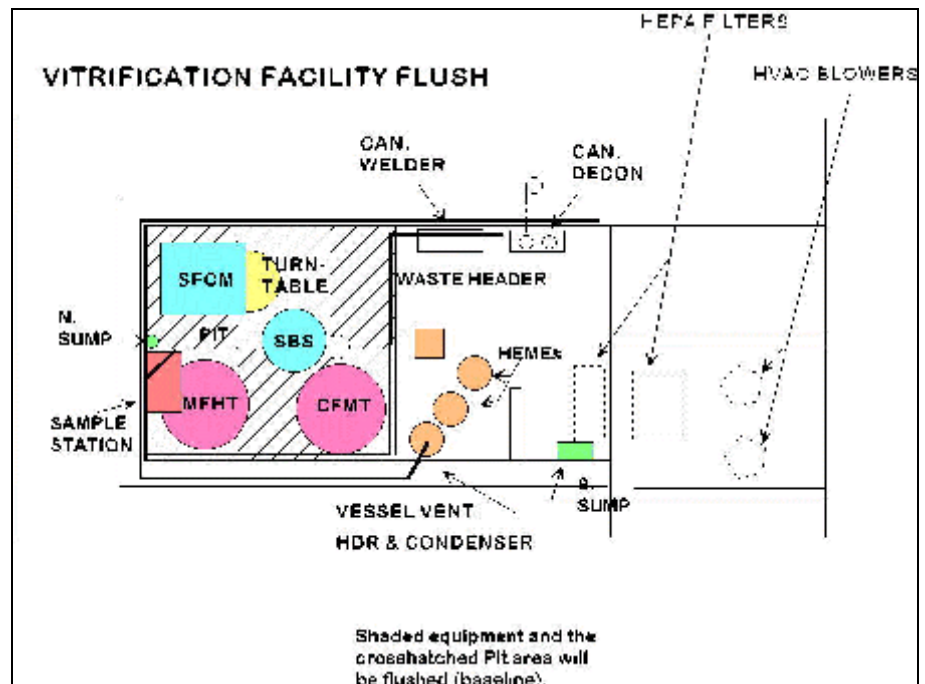


Fig. 6. Equipment to be Flushed During the Final Stage of Vitrification Operations

those components. This is not an insignificant task, but it can be accomplished much less intrusively and in a shorter time than can characterization for ultimate disposition.

Measuring Residues in HLW Tanks

In Tanks 8D-1 and 8D-2 there are two main components of waste residues: fixed and mobile contamination. The fixed waste is fixed to tank surfaces or located in unagitated parts of the tanks. In either case, it must be dislodged in order to be mobilized and retrieved. The mobile contamination is that material that can be readily fluidized with existing mobilization pumps and be retrieved with the existing transfer pumps. A number of technologies are being deployed to quantify the fixed and mobile waste residues in the HLW tanks.

There are somewhat different behaviors for the mobile waste in Tanks 8D-1 and 8D-2. The waste in Tank 8D-2 is very fine, and with mobilization pumps running, the tank acts as a well-mixed tank. The waste in Tank 8D-1 has two constituents: some fine waste solids which mix well and remain in suspension, and larger zeolite particles that can be moved with mobilization pumps, but which settle quickly to the tank floor. These behaviors have led to somewhat different techniques for quantification. Waste from Tank 8D-2 has been transferred to the VF in ~5,000-gallon batches, well over 100 times. Once in the VF, the waste is sampled and analyzed for the preparation of HLW glass. Data from these samples, in combination with tank level indications, provide accurate information about the mobile residues in Tank 8D-2. In Tank 8D-1 data is available from direct sampling; however, this is predominately the easily suspended material. Indications about the combined mobile material in the tank are only available by combining information from several sources. Video camera inspections can be used to estimate the total volume of solids. Process knowledge from supernatant treatment provides the amount of Cs-137 loaded on a given quantity of zeolite. Transfers from 8D-1 to 8D-2 are monitored with in-line gamma dose measurements, and in-tank dose rate models of the tank provide an indication of the Cs-137 source-term. Finally, data is also extracted from transfers from 8D-2 to the vitrification process.

In terms of fixed waste, several techniques are applied to arrive at an accurate forecast of the contents of the HLW tanks. A wall-scanning detector has been developed to obtain beta and gamma dose rate measurements and from which Cs-137 and Sr-90 concentrations can be determined for each area that has been scanned. A sample system has been developed to obtain waste samples of the surfaces in the tank. These two capabilities are combined with surface areas to determine the isotopic distribution of waste residues fixed to the tank surfaces.

The ability to access all surfaces in the HLW tanks is very limited. In order to maintain waste retrieval capability, only one riser is available for deploying instrumentation for in situ measurements. This has led to the development of techniques that can assess the homogeneity of residues on surfaces that can not be accessed directly. To evaluate the homogeneity, gamma camera systems have been developed that can identify, quantify, and allow visualization of those areas of the tank with higher rates of gamma-emitting radionuclides. This allows the assessment of the effectiveness of actions to washdown tank surfaces and directs sluicing operations to extract mobile residues from dead spots in the tanks. It also allows the adjustment of quantity estimates derived from more direct measurements.

Over and above these activities, some additional information may be obtained from some other more experimental techniques. For example, solid state neutron detectors have been deployed in the HLW tanks to evaluate the neutron flux at various tank locations. Based on process information about the HLW, it is expected that the majority of the neutrons are from spontaneous fission of Cm-244. Modeling of the relationship between neutron

flux and the locations of possible Cm-244 sources provides some additional understanding of nuclide quantity and distribution in the HLW tanks.

Measuring Residues in Process Systems

The balance of process systems are not being assessed in the near term for final classification. Rather, instrumentation and sampling are designed to measure whether there is significant material to be retrieved by flushing and to assess the progress of flushing steps that are being applied to piping and equipment. The principle instruments are gamma radiation dose instruments and video cameras. The gamma dose instruments are placed in key locations external to piping and inaccessible tanks. The before, during, and after dose rates are measured to determine whether flushing has made a significant impact on any remaining residues. The video cameras are being used to assess the internal conditions of accessible tanks before and after flushing. These instruments are supplemented with sampling at locations with sample collection capability. For example, both the receiving tank downstream from the STS and the CFMT in the VF can be sampled to assess the continued effectiveness of the flushing process.

SUMMARY AND STATUS

The HLW tank retrieval process has been predominately completed for the mobile fraction of the residues. Some additional zeolite and Cs-137 will be retrieved during the flushing process that should place the mobile fraction of the remaining residues well below Class C concentrations following stabilization. The processes that are effective for retrieval are the same ones that were effective at the beginning. It is difficult to do better than the dilution model for reasonably well-mixed tanks. The characterization process has identified some fixed waste on the walls of 8D-2 that would be greater than the Class C criteria. Plans are underway to remove a significant amount of that residue for transfer to the vitrification process. Methods being considered are varied, including spray lances, water monitors, and ultrasonic devices. The goal remains to get the tank structures and associated residue to Class C concentrations.

The WIR process is underway for HLW Tanks 8D-1 and 8D-2. The limiting criterion appears to be meeting Class C criteria. The other criteria appear to be satisfied with significantly greater residual waste than the Class C criteria would allow.

In order to ensure that WIR determinations will ultimately be successful for the other process systems used to transfer and treat HLW, a flushing process has been designed. The process focuses on flushing as much HLW residue through the systems to the vitrification melter as practical. Because the equipment involved is more readily removable than the HLW tanks, the other two criteria will not be explicitly addressed until later. This will allow the shutdown of the vitrification process without an extended period of equipment characterization.

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