Safety Evaluation of the ESP Sludge Washing Baselines Runs (u)

by

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SAFETY EVALUATION OF THE ESP SLUDGE

WASHING BASELINE RUNS (U)

October 1995

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REVISION LOG

<u>Revision</u>	<u>Date</u>	<u>Changes</u>
1	8/94	The inhibitor addition to the tank for corrosion control is revised to conform to Technical Standard of the Tank Farm instead of being fixed at one temperature.
2	10/95	<p>The following changes are in this revision:</p> <ul style="list-style-type: none">- Objectives of the Baseline Runs are revised to do sludge washing in Tank 51H only and not in Tank 42H.- Temperature limit for the corrosion control is revised to include the temperature measurement uncertainty.- Waste tank deflagration accident is revised to incorporate the new analysis for hydrogen deflagration in the waste tank.- Vehicle crash accident is revised to include the new operating information. Consequences of ESP wash water are calculated and compared with Tank Farm AB documents.- Revised the estimate for radiological exposure to workers during normal operation.- Safety Evaluation Report (SER) Issues.- Other minor changes highlighted by revision bars.

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1.0 Introduction and Summary

The purpose is to provide the technical basis for the evaluation of Unreviewed Safety Question for the Extended Sludge Processing (ESP) Sludge Washing Baseline Runs. The Baseline runs are necessary to resolve technical questions associated with process control; i.e., sludge suspension, sludge settling, heat transfer, and temperature control. These issues need to be resolved prior to resumption of normal ESP operations. It also addresses the open issues of the DOE Safety Evaluation Report (Ref. 32).

The equipment used for the Baseline runs are Tanks 42H and 51H and their associated equipment.

The Safety bases for these Baseline Runs are described in Section 4.

The risk from the Baseline Runs does not exceed the risks previously determined in the Tank Farm Safety Analysis Report (SAR) (Ref. 7), Justification for Continued Operations (JCO) (Ref. 15), and ITP SAR Addendum (Ref. 28). The offsite (Figure 2) and onsite (Figure 3) doses from the potential accidents are below the WSRC 9Q and E-7 guidelines, respectively.

There will be an additional exposure of 325 millirems (estimated) to workers from extensive sampling needed during the 7 month duration of Baseline Runs.

The ESP Sludge Washing Baseline Runs can be performed without undue risk to operating personnel, the public, or the environment.

2.0 Background

The insoluble nuclear waste (sludge), which is currently stored in below-ground tanks, will be prepared for processing at the Defense Waste Processing Facility (DWPF) as part of the Integrated Waste Removal Program for Savannah River Site. Part of preparation requires washing of sludge in ESP tanks.

Sludge washing was originally authorized by a Test Authorization (Ref. 1). Sludge from waste tanks 15H (left in tank 42H from 1983 Demonstration), 17F, 18F, 21H, and 22H were transferred into tanks 40H, 42H and 51H. Washing in Tanks 42H and 51H began early in 1987. During 1987 and 1988, four washing cycles were completed in tank 42H and three in tank 51H. During this operation, contamination of portions of the tank tops was observed. These incidents resulted from the leakage of slightly contaminated bearing water from the packing gland used to seal the slurry pump's drive shaft and the bearing water housing. At that time it was decided to suspend sludge washing activities until an engineered solution for the leakage problem was in place. The solution to the problem was to replace the packing seal with a mechanical seal and to install secondary containment for the area surrounding the mechanical seal. In April 1993, these modifications were completed.

During 1993 and 1994, sludge washing was restarted in both tanks 42H and 51H for an ESP process verification baseline program. On the basis of sludge depth measurements and slurry sample results taken during these baselines, complete suspension of the tanks' sludge was not accomplished (Ref. 2). In tank 51H, slurry pump mechanical seal problems resulted in excessive leakage of bearing water into the tank. The high bearing water leak rate limited the number of pumps that were operated as well as their operating speeds. The condition of at least two of the slurry pumps in tank 51H has continued to degrade. Attempts to reduce leakage by adjusting the pumps' impeller clearance (to increase pre-load on the pumps' mechanical seals) and repairing bearing water valves inside the pumps' containment cans did not reduce leakage. Recently, a decision was made to replace two of tank 51H's slurry pumps with pumps previously bought for another tank. These pumps are being retrofitted with a new more precisely machined impellers, shafts, and mechanical seals.

During the 1994 baseline effort, the tank 42H slurry pumps did not leak bearing water excessively but had other problems. Two of these pumps did not pump sludge adequately. One pump did not produce the expected loading -- measured by the motor's amperage. The pump's performance indicates that either the pump's inlet, volute or discharge was completely plugged or the pump's impeller or volute was damaged. The other pump appeared to be working in a finite sludge volume, in a "cavern." The pump had little or no effect on the bulk of the tank's sludge. It was concluded that the operation of this pump caused localized heating that eventually resulted in pump cavitation (Ref. 2).

Additional baselines for tank 42H have been deferred. It is recognized that baselining may be required for tank 42H in the future.

Current testing in tank 51H has demonstrated that the existing pumps are unable to fully suspend the sludge when either there are less than four pumps operating or when the pumps operate at speeds slower than design (Ref. 2). Although not as efficient a wash as having all four slurry pumps operating at their design conditions, soluble sodium will be reduced by performing a wash with less than four pumps at reduced speed. Because of the extensive modifications being made to the slurry pumps to correct mechanical deficiencies and schedule restraints, an additional wash may be performed before all the impaired slurry pumps have been replaced.

3.0 Objectives of the Baseline Runs

The primary objective of the Sludge Washing Baseline Runs is to demonstrate that the facility can wash sludge to support the DWPF and Integrated Waste Removal Program. Figure 1 is a flow schematic of the sludge washing process. Specific objectives of the Baseline Runs are listed below (Ref. 25):

- Evaluation of the performance of the ESP processing equipment located on Tank 51H.

- Determine operating parameters of slurry pump for suspending solids. These parameters will include operating time versus cleaning radius, and operating time versus solids and salt concentration.
- Determine slurry settling rates for optimization of sludge washing and settling cycles.
- Provide temperature and heat balance data for bench-marking ITP and ESP heat balance modeling program (Ref. 3).
- Provide a representative sample of Tank 51H sludge. Sludge sample will be used to estimate the final composition of the first feed provided to DWPF.
- Provide training for operators and laboratory personnel on the ESP process.

3.1 Baseline Description

This program is under the guidance and review of the ITP/ESP Joint Test Group. The Joint Test Group has representatives from Engineering, Operations, Startup, Quality Assurance and DOE.

The sludge washing baseline runs consist of three washing cycles:

Cycle 1: The first wash cycle was a typical wash sequence for both tanks 42H and 51H. The wash cycle included the following steps:

- The addition of corrosion inhibitor chemicals to tank 51H.
- The transfer of wash water to tank 51H from tank 42H.
- The suspension and mixing of sludge into wash water in tank 51H.
- The settling of solids into a sludge layer in tank 51H.
- The transfer of used wash water out of tank 51H.
- The addition of corrosion inhibitor chemicals to tank 42H.
- The transfer of inhibited water to tank 42H.
- The suspension and mixing of sludge into wash water in tank 42H.
- The settling of solids into a sludge layer in tank 42H.

The first wash cycle was completed during 1993 and 1994.

Cycle 2: The second wash cycle is for tank 51H only. It will have the following steps:

- The transfer of Cycle 1 wash water from tank 51H.
- The transfer of inhibited wash water to tank 51H from either tank 42H or Cold Feeds.
- The suspension and mixing of sludge into wash water in tank 51H.

- The settling of solids into a sludge layer in tank 51H.
- The transfer of Cycle 2 wash water from tank 51H.

In Cycle 2, the following Baseline Runs will be performed:

Suspension of sludge in tank 51H using 4 pumps or less than 4 pumps at reduced speed.

Suspension of sludge with slurry pumps indexed, optional.

Settling of solids into a sludge layer in tank 51H.

Cycle 3: The third wash cycle will be an additional washing sequence for Tank 51H only. The steps below will be followed:

- The addition of corrosion inhibitor chemicals, if necessary, to tank 51H.
- The transfer of inhibited wash water to tank 51H from Cold Feeds.
- The suspension and mixing of sludge into wash water in tank 51H.
- The settling of solids into a sludge layer in tank 51H.
- The transfer of Cycle 3 wash water from tank 51H.
- Suspension of concentrated sludge.
- Sampling of tank 51H sludge.

In Cycle 3, the following Baseline Runs will be performed:

Suspension of sludge using 4 pumps or less than 4 pumps at reduced speed.

Suspension of sludge with slurry pumps indexed, optional.

Settling of solids into a sludge layer in tank 51H.

Suspension of concentrated sludge using all four slurry pumps.

Suspension of concentrated sludge with slurry pumps indexed, optional.

Sampling Tank 51 slurry/sludge.

3.2 Corrosion Control and Sampling

In performing sludge washing, it is necessary to maintain a minimum amount of corrosion inhibitor in the tank liquid. The inhibitor concentration requirement is a function of nitrate/nitrite concentration ratio and maximum peak temperature occurring during processing (Ref. 4). For this series of runs, Cycles two and three, the tank liquid

temperature set points shall be set at least 4° C below the maximum temperature limit based on tank contents and corrosion control limits (Ref. 4) for the existing chemistry in the tank. This temperature limit includes the uncertainty in the temperature measurements (about $\pm 2^{\circ}$ C). The tank chemistry will be determined by periodic sampling of the tank liquid. Inhibitor additions, if necessary, are to be made prior to the introduction of wash water into the tank. High Level Waste Engineering (HLWE) will be required to specify inhibitor requirements based on the latest analysis of the supernate in the tank and planned wash liquid volume.

Operating procedures are in place to maintain the temperature in the tank below the maximum safe operating temperature (Ref. 29).

It will be necessary to sample the waste water before transferring from the tank in order to characterize the transfer (Ref. 5).

3.3 Heat Balance Data Collection

Heat balance data will be collected for the entire duration of the test program. One of the major reasons for performing these runs is to document temperatures reached during each step of processing. Heat balance models were developed at SRTC and HLWE to predict operating temperatures for ESP and ITP. To support validation of these models, it is necessary to collect temperature and flow data on an actual system.

3.4 Sludge Suspension Baseline Runs

Wash volumes to be added to the processing tank will be specified by High Level Waste Engineering (HLWE) prior to the start of each washing cycle. Procedures will contain a section for recording this information. Washing requirements are dependent upon peak temperatures (result of corrosion inhibitor requirements) occurring in the tank.

These baseline runs are intended to determine the pumping time required to suspend and mix sludge. The baseline runs begin by starting the specified slurry pumps and operating them at the specified speed. The pumps shall be operated for the intervals shown on the data sheets. The pumps will be stopped, the slurry sampled and the sludge depth measured. Then the slurry pumps shall be restarted. The steps are repeated until all specified data points and conditions have been met.

The number of intervals and interval time are based on engineering judgment using experience from previous baselining activities. In general, the unsuspended sludge level and suspended solids are expected to change rapidly during the beginning of the baseline runs but the rate of change will decrease as time continues. Therefore, the baseline run intervals shown in the data sheets are arranged to collect more information early in the baseline run and less as the baseline run continues. The number of intervals and overall

length of time for optional indexing baseline runs are shorter than for normal sludge suspension.

Sample results and sludge depth measurements will be used to determine effectiveness of suspending the sludge. The analysis of the samples will include total solids, soluble solids, insoluble solids, nitrite, nitrate, free hydroxide, and cesium-137. The concentrations of these components in the liquid are expected to increase as slurring continues. After the sludge is fully suspended, the solid concentration should become constant within the range of sampling and analytical errors. Sampling and sludge depth measurement schedules are listed in individual data sheets. Sample results will not be immediately available to determine when to stop the suspension baseline. However, sludge depth measurements will be available. This information will be evaluated continually by HLWE and may result in early stopping or extending slurring activities. The expected duration of each sludge suspension baseline is provided in the baseline sheets. Optional sludge suspension baselines may be performed if the planned baselines do not meet baseline requirements. These optional baselines provide for aligning the slurry pumps' discharge directly at unsuspended sludge with the turntables stopped (indexed).

The baseline runs specify the conditions that are expected to provide sufficient information to complete the objectives defined in Section 3.0. However, deteriorating equipment conditions which are not easily rectified may require deviating from the specified plan by operating a pump(s) at a lower speed than specified or by not operating the pump(s) at all.

3.5 Settling Baseline Runs

Settling baseline runs involve determining the time required for fully suspended solids to separate from the liquid. The effectiveness of removing soluble salts from the sludge for a cycle is dependent on the percentage of the wash water that can be removed from the sludge at the end of each washing cycle. The settling step is the most time consuming part of a washing cycle. Settling progress is determined by measuring the height of the clear liquid/suspended solids interface over time. A turbidity meter is used for determining the interface height.

3.6 Concentrated Sludge Suspension

The sludge will be transferred from tank 51H to DWPF in approximately 6000 gallon batches. The slurry transferred is expected to be uniform in composition and concentration from portion to portion throughout the period needed to process entire sludge batch of tank 51H at DWPF (Ref. 17). Since dilution of the slurry with bearing water will occur while slurry pumps are operating, it is important to minimize slurry pump operations. This baseline will determine the slurry pump operating time required to suspend and mix sludge at concentrations expected during slurry transfers. Sludge

whose wash water has been decanted from the settled sludge is representative of the sludge concentration expected for DWPF.

The number of intervals and interval time are based on engineering judgment and experience from previous baselining activities. In general, the unsuspended sludge level and suspended solids are expected to change rapidly during the start of the baseline but the rate of change will decrease as time continues. Therefore, the baseline intervals are designed to collect more information early in the baseline and less as the baseline continues. The number of intervals and overall length of time for optional indexing baselines are shorter than normal sludge suspension baselines. For indexing to be a viable alternative to normal sludge suspension, it must show an improvement in a relatively short time.

Concentrated sludge suspension baseline begins by starting the slurry pumps and operating them at design speed. The pumps shall be operated for the interval specified in the baseline data sheet. The pumps will be stopped, the slurry sampled and the unsuspended sludge depth measured. Then the slurry pumps are restarted. The steps are repeated until all specified data points and conditions have been met.

Sample results and the unsuspended sludge depth will be used to determine pump operating time required for suspending the sludge. The analysis of the samples will include total solids, soluble solids and insoluble solids.

The baseline runs specify the conditions that are expected to provide sufficient information to complete the objectives defined in Section 3.0. However, deteriorating equipment conditions which are not easily rectified may require deviating from the specified plan by: operating a pump(s) at a lower speed than specified or not operating the pump(s) at all.

3.7 Equipment Used for the Baseline Runs

The equipment for the remaining sludge washing runs includes tank 51H, the transfer lines (42H to DB-7, DB-7 to 51H, 51H to 43H), four Quad volute slurry pumps, a transfer jet located in Tank 51H and the "Cold Feeds Inhibited Water" makeup and addition system.

Tanks 42H and 51H are type IIIA waste tanks located on the New Hill section of H-Area tank farm. A complete description of type IIIA tank construction and operation can be found in the Tank Farm SAR (Ref. 7).

The Quad volute slurry pumps used in tank 51H are 45 feet long having the pump volute located near the bottom of the tank. Each pump is provided with a 300 hp motor. The pumps are designed to discharge approximately 5200 gallons per minute at 2210 rpm through two 3.62 inch diameter nozzles. The pumps are supported on a turntable that slowly rotates. The pumps drive shafts are supported by bearings located inside the

support column. The bearings are cooled and lubricated by the bearing water system. Mechanical seals are provided at the bottom and top of the support columns to prevent contamination of the bearing water with tank fluids. The pumps were tested using synthetic sludge at the TNX facilities at Savannah River Site, and have a reported effective cleaning radius, the horizontal distance from the pump discharge for complete removal of sludge, of 40 feet (Ref. 8).

The potential erosion corrosion of the waste tanks and the cooling coils due to the operation of slurry pumps at various conditions was evaluated (Ref. 45-47). The effect on the cooling coils is calculated by extrapolating the lower velocity experimental data (54 ft/sec) (Ref. 45) to higher velocity (90 ft/sec) experienced by the cooling coils (Ref. 47). These studies indicate that the metal loss rate in the tanks and the cooling coils should be insignificant for velocities up to 90 ft/sec, i.e., less than 1 mil per year (Ref. 47).

The study in reference 46 concluded that the increase in nozzle diameter of the Quad volute slurry pumps would not increase the force applied to the cooling coils in the region close to the pumps where the forces are large enough to be of concern.

The bounding consequence of the slurry pump operation could be the failure of the cooling coils. The cooling coil failure would result in decreasing the cooling capability that could affect the temperature control capability in the tank during slurring operation. The cooling coil failure would also result in the addition of the chromated water to the tank and in siphoning the waste from the tank to the surface if the cooling water header also fails simultaneously. The controls to prevent the siphoning of the waste are discussed in Section 4.3.1. The increase in the tank level caused by the addition of the chromated water is controlled by the OSRs and PRs (Ref. 4, 37).

In performing sludge washing, it is necessary to measure the depth of the unsuspended sludge/supernate interface in the process tanks. One method used to measure the unsuspended sludge/supernate interface is the steel tape method and/or the modified reel tape method. A thin flat disk is attached to a steel measuring tape and lowered into the tank through a riser. When the disk contacts the sludge layer, the tape will begin to go slack. The tape is tensioned and the distance from the riser is recorded. The sludge depth is calculated from this measurement.

The turbidity meter also is used to measure the interface between clear (unclouded) supernate and slurry or sludge. The turbidity meter consists of a light source, a photoresistor, and electrical cable. To measure the interface height, a length of cable is attached to a steel tape. A light bulb is connected across two of the cable conductors. A photoresistor is connected across the remaining two conductors. The battery is connected through the cable to the light bulb and an ohmmeter to the photoresistor. The photoresistor and light are slowly lowered into the supernate through a riser. When the photoresistor reaches the interface level, the reading on the ohmmeter will deflect upscale. At this point the distance the photoresistor is away from the riser top is recorded. The interface height is calculated from this measurement.

Both methods will measure interfaces within 2 inches. However, the two methods measure different interfaces. The turbidity meter will determine the height of clear supernate/suspended solids interface. The steel tape method determines the interface between well-settled solids and liquid. However, the two methods will converge to approximately the same height as settling continues.

4.0 Safety Information

The Safety Authorization Basis Documents for performing these runs are in the HLWMD Authorization Basis Lists Manual (Ref. 6).

A Periodic Process Hazards Review has been performed (Ref. 9). All applicable PHR action items were closed prior to the start of the sludge washing testing.

All activities performed during the runs will be accomplished within the operating boundaries and limits required by the HLWMD Authorization Basis Lists Manual (Ref. 6). Operating testing procedures and procedure changes will have a Technical Review that includes USQD Screening Review.

The Tank Farm SAR (Ref. 7) describes sludge washing but does not analyze the risks associated with sludge washing. This section addresses the risks associated with washing the existing sludge in tanks 42H and 51H.

The risks associated with the sludge washing include:

- The presence of flammable gases
- Fissile materials
- Hazards, both personnel and environmental, associated with processing radioactive sludges and solutions:
 - Radiation
 - Airborne radioactivity
 - Radioactive contamination

The risk, during the ESP Baseline runs, from potential accident scenarios, and safeguards either in place, or planned are discussed below.

4.1 Nuclear Criticality Safety During Washing of the existing sludge in Tanks 42H and 51H

Sludge samples of tanks 42H and 51H show dilute concentrations of fissile material with an abundance of Fe, Mn, and other diluents (Ref. 5). The fissile material concentration and areal density are significantly less than the published single parameter fissile material limits for Pu-239 in uniform aqueous solution (Ref. 5). The Fe and Mn to fissile material weight ratios are in excess of the calculated safe values (Ref. 12, 13). The Fe and Mn remain predominantly in the sludge during washing (Ref. 14). Sample analysis completed on tank 51H wash water after completing the first wash cycle shows an insignificant amount of Fe and Mn removed from the sludge. The ratio of neutron absorbers, Fe and Mn, to fissile materials in the sludge was unchanged during washing (Ref. 31). Therefore, the large margin of safety associated with the Fe and Mn to fissile material weight ratios will not be affected by continued washing of tanks 42H and 51H.

The soluble concentration of U and Pu in alkaline solutions is limited and is much less than the safe concentrations determined by their solubility limit. Thus it is impossible to assemble a critical mass with soluble U and Pu in alkaline ESP wash water.

The major fissionable elements of concern in evaporating ESP wash water are uranium and plutonium. ESP wash water is different from normal evaporator feed in that the concentration of dissolved salts is lower. When ESP wash water is evaporated a larger volume reduction is achieved thus there is the possibility of concentrating U and Pu more than with normal evaporator feed. The possibility of a criticality resulting from U and or Pu precipitating from ESP wash water in the evaporator has been evaluated [5] and shown to be incredible. The amount of Pu that is removed from the sludge during washing is insignificant and the inventory of uranium is depleted in the U-235 isotope. During the 1983 ESP demonstration that included aluminum dissolution and washing, only 15 grams of Pu (Ref. 14) was solubilized and transferred to the evaporator system in five decants totaling over 3.4 million gallons. During the three washing decants of the demonstration, less than one gram was transferred to the evaporator system in 2.4 million gallons of wash water (Ref. 14). More recently the first wash cycle in tank 51H was completed for the ESP Baseline Runs. The wash water contained 8 grams of Pu-239 in approximately 0.5 million gallons of wash water (Ref. 31). This is less than 2% of the safe mass for Pu-239. If the entire volume of the decants were boiled to dryness in the evaporator, there is insufficient fissile material for a critical mass. Since the uranium inventory is depleted in U-235, any uranium that is transferred to the evaporator system will be safe regardless of total mass, geometry or concentration (Ref. 5).

The ESP supernate will be sampled after settling and prior to decant, for Pu (isotopics also), U (isotopics also), Fe, and Mn. The sample results will be used by High-Level Waste Engineering (HLWE) to confirm the criticality safety technical basis of the evaporator system. The sample results will not be used as a control since there are no controlling limits.

4.2 Accidents Analyzed in the Tank Farm SAR

There are many routine conditions, unusual conditions, and/or operations considered in the Tank Farm SAR (Ref. 7), which are applicable during ESP washing baseline runs. Each of these considerations was examined for its effect on personnel at the work site, at adjacent onsite facilities, and outside site boundaries. Categories of postulated events include natural phenomena, externally induced events, and process accidents. Table 1 provides a listing of these events.

The principal safety concerns during the ESP washing baseline runs arise from potential process accidents, such as an explosion. The potential for damage from natural disasters and other externally caused events also contributes to operating risk. The critical exposure pathway from a major release at tanks 42H and 51H would be through the air and surface pathways. Airborne contamination is the dominant contributor to onsite risk, and surface releases are the main contributor to the offsite risk.

Table 2 provides offsite dose, frequency, and risk for each postulated accident using ICRP-30 dose conversion factors and 1982-86 meteorological data (Ref. 15, 16). The doses for postulated airborne releases are calculated by AXAIR89Q computer code (Ref. 15). The doses for postulated liquid releases, except for earthquake (methodology contained in Reference 15), are calculated using the LADTAP II computer code (Ref. 15, 16). The offsite doses are below the WSRC 9Q guideline (Ref. 18) as shown in Figure 2.

Table 3 contains the onsite dose, frequency, and risk for each accident (Ref. 15). The onsite doses are below the WSRC E7 guideline (Ref. 11) as shown in Figure 3. The doses are calculated using 50% meteorology and a distance of 120 meters (distance of onsite workers). It should be noted that no established DOE onsite limits exist for credible events, and that the WSRC E7 guidelines are very conservative with respect to the rationale used to establish the DOE offsite guidelines.

The doses, contained in Tables 2 and 3, are based on the radionuclide concentration of sludge (DWS) in the Tank Farm SAR (Ref. 7) and the ESP Wash Water (Ref. 30), but the radionuclide concentration of the sludge in tanks 42H and 51H are significantly lower (Ref. 10). Therefore, the dose calculations are conservative for potential accidents (using DWS) during the sludge washing Baseline Runs.

4.3 Additional Analyses

This section contains safety analysis and evaluation performed to determine the effect of modifications to tanks 42H and 51H, newly postulated events, and newly acquired data since the approval of the Tank Farm SAR.

4.3.1 Cooling Water Header

In 1991, a cooling water header broke in the H-Area tank farm and released contaminated water down a storm sewer that drains to the creek. As part of the incident evaluation, risk analysis of the following events was performed (Ref. 19):

- A large break in the header combined with a large break in a cooling coil inside a waste tank (Case 1).
- A large break in the header combined with a leak in a cooling coil inside a waste tank (Case 2).
- A large break in the header combined with a very small leak in a cooling coil inside a waste tank (Case 3).

In the above postulated events, the header failure would rapidly deplete the water in the surge tank, depressurizing the cooling water system. The break in the coiling coil would then allow waste to enter the cooling coils and recirculation piping. Siphoning of waste through the cooling water header would then be possible because tanks 42H and 51H are at higher elevations than the pump house and much of the header piping. The size of break in the cooling coil would control the rate of waste release.

Analysis of the above events are documented in reference 19. The calculated event frequencies are $4\text{E-}07/\text{yr}$ for Case 1, $1\text{E-}03/\text{yr}$ for Case 2, and $2\text{E-}01/\text{yr}$ for Case 3. Case 1 is considered incredible, and the consequences for Case 2 and 3 are within the envelope of the accident consequences as described in the current Tank Farm SAR (Ref. 7).

The evaluation (Ref. 19) recommended that either the minimum response time to large cooling water breaks be incorporated into the OSRs, or engineered siphon breaks be installed on the waste tanks. For tanks 42H and 51H, the siphon breaks are installed on the tank's cooling water header.

4.3.2 Underground Waste Transfer Lines

In April 1989 the Concentrate Transfer System (CTS) loop line for tanks 35 through 37 was found to be failed. Extensive testing was performed to determine the exact cause of the failure; however, the tests were inconclusive. To justify continued operation of the underground waste transfer lines, a technical review (Ref. 20), consisting of a USQD, was performed to evaluate the line failure. The evaluation justified the continued use of underground waste transfer lines for the H- and F-Area tank farms. Underground transfer lines for ESP tanks 42H and 51H have been modified to allow for the pressure testing of the secondary containment piping system. These systems will have passed a leak test prior to starting Baseline Runs.

4.3.3 Slurry/Transfer Pump Drop into the Tank

Slurry pumps for the ESP tanks were evaluated for impacting the primary/secondary bottom liner and the tank top in the event of an earthquake or a tornado. The slurry pumps will be installed and maintained to be within the maximum allowable operating level, which is based on a calculation, that conservatively assumed a free pump fall (Ref. 21, 28). This calculation ignored the steel containment cans, the tank top supporting structure, the fluid content, and included the total weight of the pump and the motor (not likely to occur, i.e., the motor may separate from the pump at the interface).

The maximum allowable heights in reference 28 shall be maintained during operation to prevent penetration into the primary or secondary liner as a result of a slurry pump falling inside a tank.

The transfer pumps meeting the conditions in reference 42 do not drop or create any other II/I hazards to the primary tank during a tornado (Ref. 43) or an EBE (Evaluation Basis Earthquake) (Ref. 44). On the basis of this analysis, the transfer pumps are not subject to the 2 ft height limitation (Ref. 21, 28).

4.3.4 Process Tank Corrosion

Sludge washing changes the concentration of soluble species through dilution in tanks 42H and 51H. During the washing activity, the corrosion of the tank wall and cooling coils could occur if the minimum amount of inhibitor is not maintained in the tank. Corrosion could be by either nitrate stress corrosion cracking or nitrate pitting. The amount of corrosion inhibitor required is a function of both nitrate concentration and liquid temperature. The following controls will be used to maintain the required inhibitor concentrations:

- Operating procedures include sampling of tank contents for corrosion initiators and inhibitors (chloride, sulfate, nitrate, nitrite, hydroxide). Samples are required to be pulled and analysis obtained throughout processing activities. The results are evaluated against the Corrosion Control Limits (Ref. 4) by the High-Level Waste Engineering (HLWE), prior to proceeding to transfer supernate to another waste tank.
- Tank temperature alarms are set at least 4° C below the maximum operating temperature limit for the inhibitor concentration. Alarm Response procedures require processing to be suspended until the tank temperature drops below the maximum setting or requires the addition of inhibitors to raise the safe operating temperature limit.
- Control Room Surveillance Round Sheets require recording actual tank temperatures periodically during a shift. Operating procedures direct

operators to take corrective actions at temperatures that are well below the alarm limit conditions.

The above controls are implemented through the operating procedures.

The ultimate consequence of tank corrosion would be liquid release to the soil. The offsite dose consequences of this accident are within the dose consequences of the liquid release caused by earthquake (Ref. 16).

4.3.5 Pump Leak or Contamination

Operating slurry pumps can contaminate the tank tops (tanks 42H and 51H) with slightly contaminated water. However, this hazard has been addressed by replacing the packed pump seals with mechanical seals and installation of secondary containment cans around the mechanical seals. Any leaks around the pump mechanical seal will be contained within the containment cans. The liquid from such a leak will drain back into the tank. Although it is unlikely that liquid can now leak through a pump, the following controls will be implemented to minimize the tank top contamination (Ref. 4, 9):

- Surveillance, a minimum of, once a day for radiation levels and for radioactive Gamma, Beta, and Alpha contamination will be made during operations of pumps.
- Area radiation (Gamma) monitors are installed on each tank top.

4.3.6 Failure to Detect a Radiation Release

It is possible that a release of contaminated liquid from tanks 42H and 51H may not contain sufficient Gamma Source (Cs-137) and therefore, will not be detected at the storm water outfall and diversion system because the existing storm water monitors detect only Gamma radiation.

The following administrative controls will be implemented, before the runs, to minimize the release of the contaminated liquid (Ref. 9):

- The two storm water outfalls for tanks 42H and 51H are storm water monitor and diversion system #'s 907-6H and 907-7H. Storm water systems 907-6H and 907-7H have a second monitor system installed that detect both Beta and Gamma activity. It alarms when the activity is above background. The storm water is automatically diverted to the retention basin on detection of either beta or gamma activity.

- All transfer procedures require the storm water system be diverted to the retention basin during a transfer. This is the most likely time that a release to the storm water system will occur.

4.3.7 Waste Tank Deflagration

The hydrogen deflagration accident in the sludge tanks of the tank farms is not credible (Ref. 26). The analysis is based on having a minimum of 9 days before flammable vapor concentration reaches Lower Flammability Limit (LFL) for hydrogen in the waste tank.

The time to reach LFL, after the loss of ventilation, in tank 51H during sludge washing is greater than 9 days (from 25% LFL to 100% LFL) when the tank is filled with waste up to the OSR Waste Tank Fill Limit (372") and bounding heat load and nitrate concentration (zero) are used (Ref. 23). Therefore, for the present sludge in tank 51H hydrogen deflagration is incredible.

For tank 42H during the remaining baseline activities, the maximum projected volume of waste in the tank is 1 million gallons (285"). The time to reach LFL in tank 42H is greater than 9 days (from 25% LFL to 100% LFL) when it contains a million gallons and bounding heat load and nitrate concentration (zero) are used (Ref. 23).

Administrative controls (Ref. 4) are in place requiring calculation of time to LFL each month and for any additions into the tank. If the calculation shows the time to LFL is less than 9 days then the addition can not be made.

4.3.8 Vehicle Crashes

The potential sludge release analyzed during vehicle crashes in the Tank Farm SAR is 8.3 gallons over a period of ten minutes (Ref. 7). This analysis was based on the design pump rate for the washed sludge. The Baseline Runs do not allow the transfer of sludge to DWPF. Therefore, the release of sludge is not considered in this analysis. However, ESP wash water transfers will be allowed.

On the basis of the existing jet pumping devices for tanks 51H or 42H, the flow rate for ESP wash water or sludge can be as high as 120 gpm. The release of material is assumed to continue until manually shut off. NUREG-0800, Standard Review Plan (Ref. 24) indicates that in the event of an accident in a commercial nuclear power facility, no credit is taken for operator action for a period of 30 minutes following inception of the accident. Therefore, the release of waste from the ruptured pipe due to vehicle impact will be assumed to occur for 30 minutes. On the basis of the maximum pump flow rate and a 30 minute duration, the maximum ESP wash water release is 3,600 gallons. The airborne and liquid pathways dose consequences are shown in Tables 2-3 (Ref. 16).

The frequency of the accident ($3.5E-5/\text{yr}$) is the same as in Tank Farm SAR.

The dose consequences of the ESP wash water (assuming no entrained sludge) are below the Tank Farm SAR consequences. The transfers of the entrained sludge content of 1.7% or below in ESP wash water will be within the ITP SAR Addendum consequences. The results are in Table 4.

In practice, the entrainment of the sludge is minimized by measuring the interface between clear (unclouded) supernate and slurry or sludge and keeping the inlet of the pumping device 18" above the interface. However, no data exists to characterize the entrained sludge in wash water. Therefore, no vehicles will be allowed near the above grade transfer lines used during wash water transfers to prevent the accident from occurring.

4.4 Chemical Hazards

The chemicals, sodium hydroxide and sodium nitrite, that will be used during the Baseline Runs are to control corrosion. Sodium hydroxide is used in bulk quantities in the Waste Tank Farms to control corrosion and is discussed in Section 5.4.21.2 of reference 7. Sodium nitrate is discussed in Section 5.4.21.2 of reference 7 and sodium nitrite belongs to the same family of compounds. Sodium nitrite (Ref. 22) has similar hazards as sodium nitrate. Therefore, it is concluded that sodium nitrite's hazards are covered in Section 5.4.21.2 of reference 7. The hazards associated with chemicals are toxicity, chemical burns, and corrosion.

Historically, the principal chemical hazard to operating personnel results from leaks, overflows, and transfer errors. On the basis of information from the 200-Area Data Bank, a leak from a chemical feed or storage tank occurs once every five years. Although no injury has ever resulted from a leaking tank, the potential for this event is present. The 200-Area Data Bank shows an expected frequency of chemical overflows from makeup/feed tanks to be once in five years. No injury from overflows has ever been recorded in the Waste Management Facilities. Chemical transfer errors do not contribute directly to personnel hazards, but increase the potential for more direct hazards such as overflows. The 200-Area Data Bank shows a frequency for transfer errors of less than once per year.

An injury resulting from chemicals can be categorized as an event unlikely to occur but possible per MIL-STD-882B. Recognizing that first-aid and medical treatment cases are classed marginal, category III mishaps, chemical related injuries are assessed IIIE (acceptable with review) by the military standard.

4.5 Releases During Normal Operation

The requirements for control of radiological releases to the environment through air or liquid effluents are controlled by Site Manuals 5Q, Radiological Controls (U) and 3Q, Environmental Compliance Manual (U). Releases resulting from normal operation of the tanks 42 and 51 are maintained As Low As Reasonably Achievable (ALARA) by the monitoring and reporting of effluent and environmental radioactive releases. Area and site ALARA goals are established, and each month offsite dose is compared with annual goals. Specified approvals must be obtained to exceed the established ALARA goals. SRS ALARA goals for radioactive release represent only a small fraction of the federal guidelines specified by DOE.

4.6 Exposure to Workers During Normal Operations (Baseline Runs)

There will be extensive sampling (about 70 samples of 100 cc and a 25 liter sample) and sludge level measurements during Baseline Runs as compared to minimal sampling during normal Tank Farm Operations. The estimated additional exposure (whole body) would be 325 millirem for the entire Baseline Runs that will last for 7 months (Ref. 27). This exposure will be spread over a number of personnel from 5 different shifts. Rad. Con Ops. (RCO) monitoring and exposure program will prevent the worker exposure from exceeding the site dose guidelines.

4.7 Safety Evaluation Report Issues

A Safety Evaluation Report (SER) from the DOE (Ref. 32), approving the In-Tank Processing Safety Analysis Report (SAR) Addendum (Ref. 28), stated Open, Implementation, and Revision issues for the ESP operations. The resolution of these issues is provided below:

Open Issue 3.3

The above ground line on tank 42H will not be used during the ESP Sludge Washing Baseline Runs. The transfer of wash water (supernate) from/to tank 42H will be made only through the below ground lines.

The transfer of wash water from/to tank 51H can be made through all of the above ground lines because they are seismically qualified except for line WT-16011 that is not seismically qualified (Ref. 34). Therefore, no transfer of wash water will be made through line WT-16011. The line WT-16011 is not expected to be seismically qualified before the transfers are made through the other seismically qualified transfer lines. Therefore, a seismic II/I interaction hazard of the line WT-16011 with the other transfer lines was evaluated. The qualitative evaluation by Structural Mechanics indicate that the line WT-16011 would not affect the other transfer lines.

Open Issue 9.6

There are two risers (C3 and E1) available on tank 51H to install backup portable exhausters within 9 days following an earthquake or a tornado/high wind causing equipment damage in the surrounding areas (Ref. 33). These risers are not dedicated for the installation of the backup portable exhauster and could be used in future. There are portable enclosures and their ventilation equipment on these risers for the Baseline Runs. These enclosures with their associated equipment can be removed and the backup portable exhauster installed within 9 days following an earthquake or a tornado/high wind causing equipment damage in the surrounding areas (Ref. 41). A safety evaluation will be completed before any different equipment is installed in these risers or on the tank top. This evaluation will show that the removal of the installed equipment from one of these risers and the installation of the backup portable exhauster in it, following an earthquake or tornado/high wind, can be completed within 9 days.

There are three risers (B2, C3 and E1) available on tank 42H to install backup portable exhausters within 9 days following an earthquake or a tornado/high wind causing equipment damage in the surrounding areas (Ref. 36). These risers are not dedicated for the installation of the backup portable exhauster and could be used in future. There are portable enclosures and their ventilation equipment on these risers for the Baseline Runs. These enclosures with their associated equipment can be removed and the backup portable exhauster installed within 9 days following an earthquake or a tornado/high wind causing equipment damage in the surrounding areas (Ref. 41). A safety evaluation will be completed before any different equipment is installed in these risers or on the tank top. This evaluation will show that the removal of the installed equipment from one of these risers and the installation of the backup portable exhauster in it, following an earthquake or tornado/high wind, can be completed within 9 days.

A safety evaluation will not be needed for sludge level/sampling operations because the equipment used for these operations is similar in size to the equipment present in the enclosures on the tank top. Also, the equipment used for these operations would stay on the tank top for a short duration (about 2 hours each time) only.

Implementation Issue 1

The uncertainty calculations for all LCO settings applicable to tanks 42H and 51H are included in the Operational Safety Requirements (OSRs) (Ref. 37) except the uncertainty calculations for HEPA Filter differential pressure and ARMs (Area Radiation Monitors). There is no need for the uncertainty calculations because the LCO value for these two settings is sufficiently conservative as shown below:

HEPA Filter Differential Pressure (dP)

SR 4.2.4.3 in reference 37 specifies a HEPA dP limit of 5.0 inch WC. The basis for this SR states that the 5 inch WC ensures that the exhaust flow path is unobstructed. Flow path obstruction is verified by SR 4.2.4.2 that requires verification of the purge exhaust flow rate. The HEPA dP will affect this flow rate, however, it is irrelevant from a safety analysis standpoint, as long as the purge exhaust flow SR is met. The 5 inch WC

is a common limit used in the nuclear industry and to SRS to determine HEPA operability from a radiological contamination control standpoint. All HEPA filters are designed and tested to the requirements of Military Specification MIL-F-51068F. This standard requires the HEPAs to be tested to 10 inch WC differential pressure. No credit is taken for the HEPA filters to mitigate the consequences of the accident analysis.

The uncertainty for HEPA dP instrumentation is 0.5 inch WC (Ref. 38,39) for tanks 42H and 51H. Therefore, with a nominal limit of 5.0 inch WC, the actual value, as read from the local indicator, could range from 4.5 to 5.5 inch WC. Obviously, the 4.5 value is acceptable since it is on the low side. The 5.5 value is also acceptable based on the above discussion. As long as the minimum purge exhaust flow requirement is satisfied, there is no impact on the safety analysis.

Area Radiation Monitors

There are no settings for ARMs in the OSRs. A spill of greater than 75 gallons of ESP wash water will alarm the ARM located at a distance of 50 feet from the center of the spill (Ref. 40). The alarm set point for the ARM is 4 mR/hr above normal background. The ARMs are checked against a source that produces a response of 3-7 mR/hr in the ARMs. Therefore, the uncertainty in the set point of ARMs is few (~ 3) mR/hr.

The consequences of a spill of 3600 gallons of ESP wash water are calculated in this Safety Evaluation (accident 4.3.8). The curie concentration of the wash water is about an order of magnitude higher than the curie concentration used in reference 40. This uncertainty does not include the contribution of sludge (1.7%) considered in the spill consequence analysis. An uncertainty of orders of magnitude in the alarm set point of ARM will be needed to affect the consequences of this Safety Evaluation. There is no impact on the Safety Evaluation if the uncertainty in the set point of ARMs is not included in the OSRs.

Implementation Issue 2

The appropriate ESP Process Requirements (Ref. 4) will be implemented before starting the ESP Sludge Washing Baseline Runs (Ref. 35).

Implementation Issue 3

Tank 21 will not be used during the ESP Sludge Washing Baseline Runs.

Implementation Issue 4

The Process Requirements (Ref. 4) define the requirements for performing the time to reach LFL calculation for the ESP tanks 42H and 51H. It uses the conservative inputs for heat load and nitrate concentration. The results for tanks 42H and 51H are in Section 4.3.7.

Revision Issues

The resolution of these issues will be included in the annual update of the In-Tank Processing SAR Addendum.

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Table 1. Accidents Analyzed by the SAR (Ref. 7)

NATURAL PHENOMENA

Earthquakes
Tornadoes
Straight Winds
Snow
Hail
Ice Storms
Lightning
Meteorites

EXTERNALLY INDUCED EVENTS

Vehicle Crash

PROCESS ACCIDENTS

Hydrogen Explosion in a Sludge Tank (42, 51)
Waste Tank Overflow
Transfer Overflows
Airborne Releases Associated with Equipment During Removal, Repair, or Replacement
Activity Bypasses Waste Tank Filter
Waste Tank Overpressurization
Transfer Leaks
Radiological Hazards to Operating Personnel
Process Hazards to Operating Personnel
Natural Phenomena Hazards to Operating Personnel

Table 2. Offsite Risk of Tanks 42H and 51H (REF. 15, 16)

EVENT NO.	RELEASE	AREA	EVENT	WASTE TYPE	RISK MAX. OFFSITE INDIVIDUAL (MREM/YR)	FREQUENCY (PER YR)	CONSEQUENCE (MREM)
1	Airborne	H	Activity Bypasses Waste Tank Filter	HHS	3.7E-03	5.00E-01	7.30E-03
2	Liquid	H	Waste Tank Overflow	ECC	1.8E-03	9.00E-02	2.00E-02
3	Liquid	H	Earthquake	DWS*	2.6E-04	2.00E-04	1.3E+00
4	Liquid	H	Transfer Overflow	DWS*	1.1E-04	1.30E-01	8.60E-04
5	Liquid	H	Transfer Leak	DWS*	1.9E-06	3.00E-01	6.45E-06
6	Airborne Liquid Liquid	H	Vehicle Crash	ESP Wash Water	5.0E-07 1.4E-06** 2.0E-09***	3.50E-05	1.43E-02 3.94E-02** 6.54E-05***
6a	Airborne	H	Vehicle Crash	ESP Wash Water with 1.7% DWS*	3.0E-04 2.7E-03** 3.8E-06***	3.5E-05	8.64E+00 7.83E+01** 1.09E-01***

* The consequences are based on the radionuclide concentration of sludge (DWS) in the Tank Farm SAR (Ref. 7), but the radionuclide concentration of the sludge in Tanks 42H and 51H is significantly lower (Ref. 10). Therefore, the dose calculations are conservative for potential accidents (using DWS) during the sludge washing Baseline Runs.

**Surface Release

***Ground (Sub-Surface) Release

Table 3 Onsite Risk of Tanks 42H and 51H (Ref. 15, 16)

EVENT NO.	RELEASE	AREA	EVENT	WASTE TYPE	RISK MAX. OFFSITE INDIVIDUAL (MREM/YR)	FREQUENCY (PER YR)	CONSEQUENCE (MREM)
1	Airborne	H	Activity Bypasses Waste Tank Filter	HHS	2.3E+0	5.00E-01	4.51E+0
2	Airborne	H	Vehicle Crash	ESP Wash Water	2.6E-04	3.5E-05	7.56E+00
2a	Airborne	H	Vehicle Crash	ESP Wash Water with 1.7% DWS*	1.6E-01	3.5E-05	4.55E+03

* The consequences are based on the radionuclide concentration of sludge (DWS) in the Tank Farm SAR (Ref. 7), but the radionuclide concentration of the sludge in Tanks 42H and 51H is significantly lower (Ref. 10). Therefore, the dose calculations are conservative for potential accidents (using DWS) during the sludge washing Baseline Runs.

Table 4 Comparison of Vehicle Crash Accident with Tank Farm Authorization Basis (AB) Documents

Frequency Category, 11Q per year	ESP SE Frequency, per year	ESP SE Consequences, mrem	Frequency in Tank Farm AB, per year	Consequences in Tank Farm AB, mrem
Extremely Unlikely, 1E-6 - 1E-4	3.5E-05(6) ^e	3.94E-02 ^{a,e}	2.0E-05 ^b	1.13E+01 ^{a,b}
	3.5E-05(6a) ^e	7.83E+01 ^{a,e}	1.1E-06 ^c	8.30E+01 ^{a,c}
	3.5E-05(2) ^f	7.56E+00 ^{d,f}	2.0E-05 ^b	1.72E+03 ^{d,b}
	3.5E-05(2a) ^f	4.55E+03 ^{d,f}	1.1E-06 ^c	5.15E+04 ^{d,c}

^aOffsite

^bTank Farm JCO (Ref. 15)

^cITP SAR Addendum (Ref. 28)

^dOnsite (@ about 100 meters)

^eSee Table 2, Surface Release

^fSee Table 3

Fig. 1 Sludge Washing Process

1. Activity Bypasses Waste Tank Filter
2. Waste Tank Overflow
3. Earthquake
4. Transfer Overflow
5. Transfer Leak
6. Vehicle Crash, airborne
- 6*. Vehicle Crash, surface water release
- 6**. Vehicle Crash, ground water release
- 6a. Vehicle Crash, airborne
- 6a*. Vehicle Crash, surface water release
- 6a**. Vehicle Crash, ground water release

Figure 2. Offsite Risk of Tanks 42H and 51H

- 1. Activity Bypasses Waste Tank Filter
- 2. Vehicle Crash, airborne
- 2a. Vehicle Crash, airborne

Figure 3. Onsite Risk of Tanks 42H and 51H