SAFETY EVALUATION OF THE ITP FILTER/STRIPPER TEST RUNS AND
QUIET TIME RUNS USING SIMULANT SOLUTION (U)

M. K. Gupta

October 1993

Westinghouse Savannah River Company
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- SAFETY EVALUATION FOR THE ITP SIMULANT RUNS

1.0 Introduction and Summary

The purpose is to provide the technical bases for the evaluation of Unreviewed Safety Question for the In-Tank Precipitation (ITP) Filter/Stripper Test Runs (Ref 7) and Quiet Time Runs Program (described in Section 3.6). The Filter/Stripper Test Runs and Quiet Time Runs program involves a 12,000 gallon feed tank containing an agitator, a 4,000 gallon flush tank, a variable speed pump, associated piping and controls, and equipment within both the Filter and the Stripper Building.

The safety bases consist of:

- Pre-operational Process Hazard Report, In-Tank Precipitation (Temporary Cold Run Facility) (Ref. 1)
- ITP Pre-Operational Process Hazard Review Report (Ref. 2)
- Draft ITP Safety Analysis Report (SAR Addendum) (Ref. 3)
- Draft ITP Operational Safety Requirements (OSR) (Ref. 4)

The chemical consequences of the accidents analyzed in Section 4 of this report are the release of volatile components, benzene and alcohol, and non-volatile components sodium titanate (ST), tributyl phosphate (TBP), sodium tetraphenylborate (STPB), sodium hydroxide (NaOH) and oxalic acid, to the atmosphere. The onsite (100 meters from the release) and offsite concentrations of these chemicals from various potential accidents are less than the IDLH and 0.01 IDLH values (Ref. 17), respectively as shown in Tables 2 and 4. The facility concentrations (10 meters and 20 meters for the surface and Feed Tank release, respectively) of volatile chemicals are below the IDLH values as shown in Table 7. The increase in lifetime Incremental Cancer Risk (ICR) values, for an onsite individual and an individual inside the stripper building from various accidents shown in Figure 5, are equal to or below the Low Hazard criteria in Facility Safety Analysis Manual (Ref. 22). The doses from the chemicals are within the existing safety envelope of the limited analysis performed in the approved Tank Farm SAR (Ref. 23) and draft ITP Addendum to the Tank Farm SAR (Ref.3).

The 8-hour and 1-hour average maximum benzene concentrations at different locations in the ITP facility during pump operation, thermal cycling, and filtrate transfer to the Feed Tank are shown in Tables 8 and 9, respectively. The benzene concentrations exceed (511 ppm) the Short Term Exposure Limit (STEL) of 5 ppm at the Filter/Stripper building during filtrate transfer to the Feed Tank which lasts 246

minutes (35 gpm transfer rate). The 8-hour average maximum concentration of benzene, during filtrate transfer, pump operation, and thermal cycling, is above the action limit of 0.5 ppm at the Filter/Stripper building. It is recommended that the access to the Filter/Stripper building (241-96H) be controlled and limited during the entire test runs. The benzene concentrations must be monitored at building 241-96H and at other locations (up to 30 meters from the Feed Tank) in the ITP Facility to determine the areas where benzene concentration is above the STEL of 5.0 ppm during filtrate transfer and benzene dissolution. If the benzene concentration is above the STEL of 5.0 ppm during filtrate transfer or benzene dissolution, then the access to those areas will be controlled.

The concentration of flammables in vapor phase from all the solutions ('Information Only' Simulant Solution and 4 transfers of inhibited water solution) transferred to Tank 48 and the existing concentration of flammables in Tank 48 will be about 25% and 30.5% (assuming all the flammables are released instantaneously) of LFL for butyl alcohol (BuOH)/benzene and benzene/hydrogen, respectively.

Considering the possibility of benzene/BuOH stratification in the vapor space of Tank 48 and of possible disturbance during the addition, the vapor space will be continuously monitored for LFL during the transfer and should the LFL increase significantly (>10% of LFL), the transfer will be stopped.

The worst onsite and offsite radiological consequences from accident 4.9, Solids Fire in Tank 50, are 5.4 rem and 8.9 E-3 rem, respectively and will occur at a frequency of 4.0 E-4/yr. The offsite and onsite consequences are significantly below the DOE/TIC-11603 guideline and WSRC 9Q guideline as shown in Figures 1.3 and 1.6, respectively of Reference 3. The risk is within the existing safety envelope of the approved Tank Farm SAR (Ref. 23) and the draft ITP addendum to the Tank Farm SAR (Ref. 3).

The risk to the Tank Farm facilities from the accidents postulated from Filter/Stripper Test Runs and the Quiet Time Runs including, Benzene/BuOH Deflagration in Feed Tank and Solids Fire in Tank 50, are bounded by the risk in the Tank Farm SAR (Ref. 23).

The Filter/Stripper Test Runs and Quiet Time Runs can be performed without undue risk to operating personnel, the public, or the environment.

2.0 Background

In-Tank Precipitation is a process for removing radioactivity from the salt stored in the Waste Management Tank Farm. The process

involves precipitation of cesium and potassium with sodium tetraphenylborate (STPB) and adsorption of strontium and actinides on insoluble sodium titanate (ST) particles; Cs-137 comprises the majority of the radioactive material present in the waste salt. Adding ST and STPB to the salt solution forms a slurry, with approximately 99.9% of the activity trapped in insoluble solids (Ref. 5). These insolubles consist of precipitated potassium tetraphenylborate (KTPB) and cesium tetraphenylborate (CsTPB), as well as strontium and actinides adsorbed on ST particles. The slurry will be concentrated from 0.5 weight percent solids to approximately 10 weight percent solids using cross flow micro-filtration. The filtrate, also known as low activity or decontaminated salt solution, contains volatile organic compounds which are formed during the precipitation process. The volatile compounds are removed by humidified nitrogen as the filtrate is passed through a stripping column. The Saltstone Facility in Z area will perform the final processing of the decontaminated salt solution while the Defense Waste Processing Facility in S-Area will perform the final processing of the concentrated slurry.

2.1 Process Description

Saltcake accumulated in the tank farm storage tanks is dissolved with inhibited water (well water mixed with sodium hydroxide as a corrosion inhibitor) and transferred to Tank 48 for processing (Figure 1). Tank 48 is the waste tank where the precipitation and adsorption process occurs. The slurry from Tank 48 is concentrated to 10 weight percent solids by repeated filtration. The concentrated precipitate is then washed with inhibited water from cold feeds to remove soluble salts. The washed precipitate is transferred from Tank 48 to Tank 49 for temporary storage before feeding it to S-Area for final disposal. The decontaminated salt solution produced from the filtration is sent to Tank 50 for eventual transfer to Z-Area. The spent wash water is transferred to Tank 22 to be used as dilution water for the next cycle. Because of the flammable vapors and combustible solids hazards associated with the organics produced by the precipitation process, both Tanks 48 and 49 have been provided with a nitrogen purge system.

The cross-flow micro-filters used for ITP are housed in stainless steel lined, concrete cells within the Filter Building. The ITP process uses two filters in a parallel arrangement. The filters are similar in appearance to shell and tube heat exchangers with the tubes acting as the filter media. The tubes in the filters are constructed of sintered 316L stainless steel powder. Slurry enters on the tube side of the filter. The pressure differential between the inside of the tubes and the shell side of the filter pushes clear liquid through the porous tube walls. The porous tubes are rated at 0.5 micron to achieve the desired decontamination factor. The filtrate produced is essentially

free of cesium and strontium insolubles. The flow of slurry through the tubes helps prevent the buildup of particles on the tube walls, thereby helping to reduce the plugging of the filter. To prevent excessive solids build up on the tubes, periodic backpulsing is utilized. A backpulse is a temporary reversal of filtrate flow accomplished by applying a pulse of high pressure nitrogen (approximately 50 psig higher than tube side liquid pressure) to the liquid on the shell side of the filter. This temporary reversal in filtrate flow tends to dislodge particles adhering to the media. During normal filtration operation, the frequency of the backpulses will be controlled by the pressure differential across the tubes.

The filtrate production rate is controlled using valves on the tube side of the filter in the slurry outlet (concentrate) line. These control valves permit the adjustment of the liquid pressure drop across the filter media. This pressure drop is the driving force for filtrate production. Slurry is continuously recycled from the processing tank, to the filters, and back to the processing tank (Tank 48). Filtrate flows from the shell side of the filter to a seal tank. The seal tanks provide a small reservoir of filtrate so the backpulse is accomplished with liquid and not gas; this is the most efficient method of backpulsing. From the seal tank, the filtrate flows to the stripping columns to remove volatile organic compounds (alcohols and benzene). After the seal tanks, tributyl phosphate (TBP) is injected in to control foaming in the stripper.

The filtrate enters a stripping column at the top and flows downward through the column packing as humidified nitrogen enters at the bottom and flows upward. The organic compounds tend to diffuse from the filtrate into the nitrogen. The organic laden nitrogen is then passed through the High Efficiency Mist Eliminator (HEME) and HEPA filters to remove droplets and contaminants before being released to the atmosphere. The filtrate is pumped from the bottom of the column to the filtrate hold tanks.

The two 12,000 gallon filtrate hold tanks are located in the Filter Building. Because of the potential for the presence of flammable organic vapors, the hold tanks are equipped with nitrogen blankets. Proper operation of the stripping columns will prevent the buildup of a dangerous concentration of flammable vapors in the hold tanks. Nitrogen blankets are provided as an additional safety measure.

3.0 Filter/Stripper Test Runs and Quiet Time Runs Program

3.1 Program Scope

The primary objective of the filter/stripper test runs and quiet time runs program is to ensure that the facility will fulfill its design basis function prior to the introduction of radioactive feed.

The safety envelope for ITP Filter/Stripper Test Runs and Quiet Time Runs consists of the applicable PHR actions from PHR 200-H-486 (designated in the ITP Punchlist), all PHR actions from PHR 200-H-493, the intent of applicable ITP Operational Safety Requirements (defined in WER-ITP-920265) and the mitigation measures listed in Section 4 of this document. The interface between the ITP Temporary Facility and Tank 48 and 50 is addressed by the mitigation measures listed in Section 4 of this document and in Test Authorizations WSRC-TA-91-0005-11 (Ref. 31) and WSRC-OX-89-15-001, Rev. 4 (Ref. 8), respectively. Transfers from the Feed Tank to Tank 48 following all testing are not included in the scope of this safety evaluation except the solutions in Section 4.13. Transfer from the Flush Tank (containing neutralized oxalic acid) to Tank 50 are allowed 30 times during the tests.

The filter/stripper test program consists of three parts:

- (1) Information Only Tests - One stripper will be tested using salt solution (3.0 molar sodium) spiked with benzene and TBP. This test will provide information on the relationship between TBP and the pressure drop across the column.
- (2) Stripper Performance Evaluation - Both strippers will be tested using salt solution spiked with benzene; no solids will be present during this phase of testing.
- (3) Stripper and Filter Performance Evaluation - The strippers and filters will be tested using approximately 1.5 wt% solids slurry. The filter flux testing will be performed to determine the effectiveness of filter cleaning.

Cleaning of the system may be performed after completion of all tests unless filter or stripper performance shows evidence of degradation that would require an earlier cleaning.

3.2 Temporary Equipment Used for Filter/Stripper Test Runs and Quiet Time Runs Program

Construction of the temporary facilities to be used during this program has been completed (Ref. 6). These facilities include a simulant feed tank, chemical addition system, temporary filter feed pump, slurry return line, filtrate return line, simulant recovery system, and flush tank (Figure 2).

The feed tank has a working capacity of 12,000 gallons. It is equipped with a single speed agitator to assure thorough mixing of tank contents. The tank is constructed of 304L stainless steel. The tank is provided with an overflow line with a seal leg. The overflow

discharges to grade within the dike surrounding the tanks. The feed tank is provided with a nitrogen blanket to address flammability hazards associated with the chemical simulants. The nitrogen source is a 10 psig header. The nitrogen blanket regulator setpoint is approximately +0.5 inches of water column and at pressures less than 0.5" of WC the nitrogen supply valve will remain open. A pilot actuated regulator and a regulator by-pass line to facilitate initial tank inerting are provided. Following the initial nitrogen purge (and subsequent nitrogen purges if the blanket is lost), the oxygen concentration is verified to meet the requirement in Reference 3 using a portable oxygen analyzer. Thereafter, the nitrogen blanket pressure is maintained positive to ensure that the oxygen concentration remains within requirements.* The Feed Tank was designed for an internal pressure of less than 15 psig (Ref. 29). The tank is fitted with a conservation vent for routine pressure relief (2 psig), a vacuum relief with flame arrestor, and an emergency vent for relief (2.5 psig) of abnormal overpressurization. The tank is equipped with liquid level and vapor space pressure instrumentation. High and low blanket pressure alarms are provided. A conductivity probe (with alarm) is installed at the top of the tank to detect severe foaming of the slurry, should it occur. If foaming occurs, then the agitation and pumping will be stopped until foam dissipates.

A temporary filter feed pump will pump the simulant from the feed tank to the filter. The temporary pump is designed for low shear, slurry service. The variable speed drive for an actual ITP filter feed pump will be used to control the temporary pump, thus allowing use of system interlocks in place to prevent damage to the filters. Low feed tank level will shut off the temporary feed pump as will low flow in the temporary pump's discharge line. Pump speed is controlled from the ITP Control Room in 241-82H.

Slurry is returned to the temporary feed tank through a stainless steel pipe. The discharge from this temporary return line is below the expected operating level of the feed tank to minimize foam formation.

Process piping will route filtrate from the filter to the seal tanks, to the stripper and then to the filtrate hold tanks. A stainless steel pipe is used to return the filtrate to the temporary feed tank. This temporary line is connected to the process piping downstream of the permanent filtrate pumps, thereby allowing their use during slurry runs to return filtrate to the temporary feed tank.

* The only exception will be for inspection access into the tank after the tank atmosphere has been verified to have a benzene concentration of less than 10% of Lower Flammability Limit (LFL). After the inspection, the oxygen concentration will be restored to within requirements.

The temporary facilities include a nitrogen blanketed flush tank* to temporarily hold flush water used to clean the system. The tank is equipped with a conservation/vacuum vent with a flame arrester and an emergency vent. Tank instrumentation includes level indication and blanket pressure. Both high and low blanket pressure alarms are provided.

3.3 Simulant Selection and Preparation

For 'Information Only' tests, approximately 8000 gallons of 3.0M sodium salt solution will be pumped through the system with benzene and TBP added and maintained near solubility levels.

For Stripper Performance Evaluation, approximately 7500 gallons of salt solution will be added to the simulant Feed Tank. Table 1 contains the salt solution composition for the stripper test runs. The salt solution will be spiked with benzene to perform the stripper tests. Data will be taken on the stripper columns using a solution that contains up to approximately 1038 mg/liter of benzene.

For Stripper and Filter Performance Evaluation, sodium tetraphenylborate (STPB) will be added (and maybe sodium titanate (ST) also) to the salt solution to initially form an approximately 1.5 wt % solids mixture. Solids (potassium tetraphenylborate, or KTPB) are formed by a precipitation reaction of the potassium in the salt solution and the STPB. The detailed composition of the simulant is presented in Table 1. The Material Safety Data Sheets (MSDS) are available in the 241-82H control room. The procedures for chemical addition and chemical unloading include personnel protection appropriate for chemical exposure hazards. These procedures have been reviewed by an Industrial Hygienist.

3.4 Stripper Tests

The tests involve running the ITP filters with either decontaminated salt solution (DSS) stripper (column 1) or the wash water (WW) stripper (column 2) and collecting stripper bottoms in a Filtrate Hold Tank 'Information Only' (Ref. 7).

- 3.4.1 For 'Information Only' stripper columns testing, benzene will be added to the simulant Feed Tank via a small chemical addition pump to achieve the "worst" case concentrations of approximately 450 ppm (Ref. 27).

* The only exception will be for inspection access into the tank after the tank atmosphere has been verified to have a benzene concentration of less than 10% of Lower Flammability Limit (LFL). After the inspection, the oxygen concentration will be restored to within requirements.

- 3.4.2 For stripper column acceptance tests, benzene will be added to the Feed Tank via a small chemical addition pump to achieve a concentration of up to approximately 1038 mg/liter of benzene.

3.5 Stripper and Filter Performance Tests

The tests involve filtrate production and concentration of the simulant in the simulant Feed Tank. The filter efficiency and filter flux (gpm filtrate/sq ft filter area) will be evaluated. To prevent excessive solids buildup on the filter media, periodic backpulsing will be utilized.

- 3.5.1 An approximately 1-4 wt% solids concentration simulant will be initially prepared by adding STPB (and maybe ST also) to the salt solution. The filter will be tested using solids concentrations from approximately 1 - 10 wt% solids (Ref. 7).

3.6 Quiet Time Runs Program

The Quiet Time Runs Program consists of a series of training exercises where filtration, benzene stripping, filtrate hold tank transfers, and component cleaning operations are performed. These training exercises will follow Filter/Stripper Test Runs and will use the same equipment configuration and safety controls as Filter/Stripper Test Runs. The training exercises will include both normal process operations, support operations such as Filter/Stripper Building ventilation and simulated alarms or off-normal operations. Alarms and off-normal conditions will be simulated by written or verbal communication rather than by instrument or process manipulation.

3.7 Equipment Cleaning and Storage

When the system is shut down after filter, stripper or Quiet Time Runs, the simulant will be transferred to the Feed Tank. Cleaning operations, as needed, will be performed on the filters, hold tanks and the strippers as the final segment of Simulant Runs and Quiet Time Runs, in preparation for storage of the equipment while the system is prepared for the beginning of "hot" runs. Cleaning will also be performed should the filters or strippers become unacceptably fouled (i.e. high differential pressure). Water and oxalic acid will be used for cleaning, and the waste cleaning solution, after it is neutralized with caustic, will be transferred to Tank 50.

- 3.7.1 If required, the filters will be cleaned, by initially flushing the filter tube-side with water while backpulsing as needed, then cleaning/backpulsing with oxalic acid (OA). After the OA cleaning, the filters will be flushed/backpulsed with water again from the shell side.

- 3.7.2 ~~The~~ strippers will be cleaned in the same way as the filters, by filling with water, cleaning with OA and filling with water.
- 3.7.3 If required, the Hold Tanks will be cleaned using the installed rotary sprayers to flush the tank walls with water and OA solutions. The filter cell sump will not be cleaned unless material is spilled in the sump.
- 3.7.4 If cleaning is conducted during the test program, the filter or stripper will be left in wet lay-up until the next test. After all testing has been completed, the filters and strippers will be cleaned and left in wet or dry lay-up.
- 3.8 Disposition of Water Flushes & Simulants
- 3.8.1 During simulant runs it will be necessary to transfer flush water and cleaning solutions from the Flush Tank to Tank 50. All solutions will be sampled and analyzed for chemicals and pH prior to transfer to ensure that the liquid meets the requirements (see note) listed in the Test Authorization (Ref. 8) and Technical Standards (Ref. 9) governing these transfers.

Note: Alcohol analyses will not be required until sodium titanate is introduced into the test facility. Since the test solutions are not radioactive, radionuclide analyses will not be required.

- 3.8.2 After all the simulant runs are complete, the simulant will be collected in the Feed Tank. The Feed Tank will be isolated and the nitrogen blanket maintained until the solution is transferred to Tank 48. The 'Information Only' simulant solution (Table 10) and 4 transfers of inhibited water (Table 11) solution to Tank 48 will be allowed (section 4.13 addresses their hazards in Tank 48). After these transfers, the pipe from the Feed Tank to Tank 48 will be isolated before stripper column acceptance runs testing is started and transfer pipe will not be operational until the safety implications of the addition of this solution (used in the stripper column acceptance runs) to Tank 48 are addressed.

4.0 Safety Information

This section addresses new risks associated with the filter/stripper test runs and quiet time runs program in the previously identified ITP facilities. This analysis does not address the risks associated with the radioactive operation of the permanent ITP facilities; these risks are addressed in the draft ITP Addendum (Ref. 3). The filter/stripper test runs and quiet time runs will operate the permanent ITP facilities in about the same manner as actual ITP operation. The intent of the applicable OSRs will be implemented through procedures even though the draft OSRs (Ref. 4) are not approved (Ref. 39). In addition, the Process Hazards Review (PHR) for the temporary facilities (Ref.

1. PHR for Tank 50 transfers (Ref. 10) and TA for those transfers (Ref. 8) have been completed.

The risks associated with the filter/stripper test runs and quiet time runs program of ITP include:

- hazards, both personnel and environmental, associated with handling the chemical simulants
- the presence of flammable materials
- the potential for damage to the permanent ITP and Tank Farm facilities

The risks, potential accident scenarios, and safeguards either in place or planned are discussed at length below.

4.1 Chemical Spill at Temporary Facility

Background The following cold chemicals are used during simulant runs:

1. Benzene (22 x 5 gallons)
2. Sodium titanate (ST) (contains up to 3 volume percent of methyl and/or isopropyl alcohol) (3 x 55 gallons) may be used
3. Sodium tetraphenylborate (STPB) (contains up to 650 ppm of benzene) (5000 gallons)
4. Oxalic acid (up to 4 weight percent) (1000 gallons)
5. NaOH (up to 25 weight percent) (1000 gallons)
6. Simulant Salt Solution (8000 gallons)
7. Tributyl Phosphate (TBP) (12 x 5 gallons)

The 22 bottles (5 gallon each) of benzene are analyzed in the accident, but only 4 bottles at a time will be used during the simulant runs.

A spill to the dike may constitute a release reportable to certain governmental agencies, including the South Carolina Department of Health and Environmental Control (SCDHEC).

Initiators Some typical causes of accidental releases of chemicals are overflows, transfer errors and leaks.

Frequency Some historical data on leaks of chemicals supplied to waste disposal operations are taken from the 200-Area Fault Tree Data Bank (Ref. 13). The historical frequency is $6.1\text{E-}1/\text{yr}$. The duration of the entire program is only 3 months therefore, the frequency of spills is $5.1\text{E-}2/\text{month}$.

The probability of mishandling a 55 gallon drum of ST is $1.0E-2$ (Ref.12). The number of ST drums handled during all the tests are 3 drums/3 months (estimate from WME). Therefore, the frequency of the spill of the entire 55 gallon drum is $1.0E-2$ /month.

The probability of mishandling a 5 gallon bottle of benzene is $1.0E-2$ (Ref.12). The number of benzene bottles handled during all the tests are 22 bottles/3 months (estimate from WME). Therefore, the frequency of the spill of the entire 5 gallon bottle is $7.3E-2$ /month.

The probability of mishandling a 5 gallon bottle of TBP is $1.0 E-2$ (Ref. 12). The number of bottles handled during all the tests are 12 bottles/3 months (Ref. 27). Therefore, the frequency of the spill of the entire 5 gallon bottle is $4.0 E-2$ /month. •

Consequences There are no radiological consequences to this event, because no radioactive material is present. The amount of material spilled is estimated from data in the Building 211-H SAR (Ref. 21). The average spill is estimated to be approximately 0.5% of the capacity stored and the consequences of a spill of 55 gallon drum of ST and a 5 gallon bottle of benzene and TBP also are calculated.

The onsite and offsite concentrations of volatiles (benzene, methanol, isopropanol, and TBP) and of non-volatiles (NaOH and oxalic acid) contained in Tables 2 and 4 are below the IDLH and 0.01 IDLH values, respectively. The facility concentration of volatile chemicals are below the IDLH values as shown in Table 7 (Ref. 24). The duration of benzene release, shown in Table 3, is below the IDLH guideline (Ref. 17) as shown in Figure 4. The increase in lifetime Incremental Cancer Risk (ICR) values for an onsite and offsite individual are contained in Table 6. Figure 5 shows that the ICR value for an onsite individual (Table 6) is below the Low Hazard criteria in Facility Safety Analysis Manual (FSAM) (Ref. 22). The criteria did not consider the duration of release.

The concentration of volatile chemicals in the solution will decrease as it evaporates and therefore, it will be a function of time. The calculated chemical release rates are for the initial chemical concentration of the spill from a time independent evaporation model. Therefore, the release rates, facility, onsite, and offsite concentrations, are conservative.

Mitigation Mitigation measures for this event include procedural controls to prevent solution overflows. The actions are to isolate the Flush Tank while chemicals are added to the Feed Tank, to prevent inadvertent draining of flush solution into the Feed Tank, to isolate the chemical addition tank from the chemical addition pump while filling the addition tank, to isolate the Feed Tank when pumping to and from

Flush Tank and vice versa, and to stop the filter feed pump on high liquid level in the Feed or Flush Tanks. There are administrative controls for responding to chemical spills (Ref. 16). Interlocks are added to stop the filtrate pumps on high liquid level in Flush or feed tank.

The Feed Tank and Flush Tank are surrounded by a concrete dike sized to contain the contents of the tanks if they fail.

4.2 Entire Feed Tank Spill/Fire

Background The feed tank contains about 1-10 weight percent precipitate of KTPB in a salt solution which also contains benzene (up to 20 gallons), STPB, ST, (if used) and alcohol (present up to 3 volume percent in ST solution) and TBP (up to 60 gallons). Additional benzene will be generated by the thermal decomposition of STPB slurry in the Feed Tank (Ref. 25). A spill of the solution can expose workers to benzene and alcohol. If the spill is not cleaned up, the precipitate can dry out; and if there is a source of ignition, the dried precipitate can burn.

In the Feed Tank, some TBP may decompose by hydrolysis (in high pH solution) to form mono- and di-butyl phosphate and butyl alcohol (BuOH) (Ref. 32). One mole of TBP decomposes to 3 moles of BuOH (Ref. 33). The release of BuOH is analyzed but the release of mono- and di-butyl phosphate is bounded by the release of undecomposed TBP.

Initiators The most likely initiator for this event is the removal of the cap from the wrong open-ended line and leaving the isolation valve on that line open.

Frequency The frequency for the spill of entire tank is $3.0\text{E-}4/\text{yr}$ as shown in Figure 3 or $2.5\text{E-}5/\text{month}$.

Consequences There are no radiological consequences to this event, because no radioactive material is involved. A liquid temperature of 60 degree celsius was assumed in the Feed Tank (Ref. 27). The thermal decomposition of 1 wt. % unwashed STPB slurry at 60 degree celsius for 90 days can generate an additional 580 ppm of benzene in the salt solution. Therefore, the final concentration of benzene in the salt solution is about 2250 ppm. The concentrations of flammables, benzene, methanol, isopropanol, BuOH, and TBP, and of non-flammables, are shown in Tables 2 and 4, respectively. The onsite and offsite concentrations are below the IDLH and 0.01 IDLH values, respectively. The facility concentrations of volatile chemicals are below the IDLH values as shown in Table 7 (Ref. 24). The duration of benzene release is below the IDLH guideline (Figure 4) and the ICR value for an onsite individual is

below the Low Hazard criteria in FSAM (Figure 5). The concentrations are based on releasing the entire 12,000 gallons of salt solution (maximum) and 2,885 gallons of vapor (minimum) (Ref. 27) in the feed tank into the dike. The contribution of vapor release is about 5% to the total release.

The onsite and offsite concentrations of volatile chemicals from the scenario 'Entire Feed Tank spill with minimum liquid' are bounded by the release of 'Entire Feed Tank spill with maximum liquid' as shown in Reference 34.

The concentration of volatile chemicals in the solution will decrease as it evaporates and therefore, it will be a function of time. The calculated chemical release rates are for the initial chemical concentration of the spill from a time independent evaporation model. Therefore, the release rates, facility, onsite and offsite concentrations, and duration of the release are conservative.

The consequences of the fire would be the release of soot and other combustion products, possibly including acrid and/or hazardous 'partial' combustion products.

Mitigation Mitigation measures for this event include double isolation (two closed valves in series or a closed valve and pipe cap in series) on all drain paths such as sample lines, drain lines and vent lines (Ref. 18). Also, administrative controls are provided to keep valves closed and pipe caps installed except when the respective line is in use. There are administrative procedures for responding to spills (Refs. 15 and 16). The Feed tank is surrounded by a concrete dike sized to contain the contents of the entire Feed Tank, in the event of a tank failure. Fire hydrants, portable fire extinguishers, and a foam that prevents the evaporation of benzene are provided in the dike vicinity.

4.3 Nitrogen Asphyxiation in Stripper Building

Background Nitrogen is used as the stripping gas to remove benzene from filtrate. Should the nitrogen leak into the building, a worker entering the building can be subject to asphyxiation because of low oxygen in the air. The accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref. 3).

Initiators Large releases of nitrogen into the building can occur at numerous points, including the pressure relief valve on top of the column or an open drain line on the venturi separator in the nitrogen supply system (Ref. 3).

Frequency The frequency is estimated as 2.2E-4/yr. (Ref. 3) or 1.8E-5/month.

Consequences The potential consequence of this accident is worker fatality if rescue and resuscitation are not successful. (Ref. 3).

Mitigation Mitigation measures include:

- Administrative controls are in place which require evacuation of the Stripper Building on loss of building exhaust, a sign-in in the control room to enter the building with normal ventilation, daily oxygen concentration monitoring by Health Protection (HP), and HP coverage as necessary for entry when there is no ventilation.
- Oxygen monitoring in the stripper building.
- Ventilation-fan-failed alarm lights at entry door.

4.4 Benzene Release into Stripper Building

Background The purpose of the stripping columns is to remove benzene from the filtrate in a counter-current flow of nitrogen. The column offgas contains benzene, but little oxygen. It is treated and vented along with the building ventilation exhaust as shown in Figure 2.14 of Reference 3. Workers can be exposed to benzene if the column offgas is released inside the building. This accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref. 3).

Initiators Large releases of offgas from a stripping column into the building can occur at the following points:

- The pressure relief valve (PRV) on top of the column
- Through the building ventilation system.

The PRV can fail to close after a pressure surge caused by a combination of high pressure in the nitrogen supply line and HEPA filter pluggage. The second initiator is a building ventilation fan failure, resulting in air reversal that draws column offgas from the stack through the ventilation ducts (Ref. 3).

Frequency The frequency for this event is $3.2\text{E-}5/\text{yr}$ (Ref. 3) or $2.7\text{E-}6/\text{month}$.

Consequences The filtrate feed rate is approximately 115 gal/min with a maximum benzene concentration of approximately 1038 mg/liter at a sodium concentration of approximately 1.75M (Ref. 27). At higher sodium concentration, the benzene solubility decreases. Therefore, the benzene solubility at this sodium concentration (1.75M) is the bounding solubility for all the tests. It is assumed that the stripping is 100 percent efficient, and all the benzene stripped from the liquid phase is in the vapor phase. Thus, the maximum benzene

release rate through the 50 ft high stack during normal operation would be:

$$(115 \text{ gal/min}) \times (3.78 \text{ l/gal}) \times (1038 \text{ mg/l}) \times (1 \text{ min}/60 \text{ sec}) \\ = 7.52\text{E}+3 \text{ mg/sec}$$

The onsite and offsite concentrations of benzene during normal operations are shown in Table 2. The maximum benzene concentration is at 100 meters for a 50 feet high stack release (Ref. 24). The onsite and offsite concentration is below the IDLH and 0.01 IDLH value, respectively.

The offgas from the stripper column can be released through a pressure relief valve into the building air with a flow of 3000 ft³/min (Ref. 7). Thus, the benzene concentration in the building air is:

$$(7.52\text{E}+3 \text{ mg/sec}) \times (60 \text{ sec/min}) \times (35.31 \text{ ft}^3/\text{m}^3) \times (1 \text{ min}/3000 \text{ ft}^3) \\ = 5.31\text{E}+3 \text{ mg/m}^3$$

Thus the benzene concentration in the building air is less than the IDLH (9.57E+3 mg/m³) value for benzene and below 25 percent of the LFL (1.04E+4 mg/m³) (Ref. 19). The duration of benzene release, shown in Table 3, is conservative because it assumes that the benzene release into the stripper building occurs at the start of the stripping operation. The onsite concentration and the concentration inside the stripper building is less than the IDLH value but the release lasts longer than allowed by the IDLH guideline as shown in Figure 4. The ICR for an onsite individual and an individual inside the stripper building is below and equal to the Low Hazard criteria, respectively as shown in Figure 5.

Mitigation Mitigation measures for this event include:

- Administrative controls are in place which require evacuation of the Stripper Building on loss of building exhaust, a sign-in in the control room to enter the building with normal ventilation, and Health Protection coverage as necessary for entry when there is no ventilation.
- Ventilation-fan-failed alarm lights at entry door

4.5 Benzene/BuOH Deflagration in Feed Tank

Background Flammable vapors can accumulate in the Feed Tank during the pumpdown of the tank if the inert blanket in the tank is not maintained. Should an ignition source be present, a fire can occur

due to air inleakage that provides a source of oxygen. A similar accident has already been analyzed in the draft ITP Addendum (accident 3.3.1.2) to the Tank Farm SAR (Ref. 3).

Initiators The inert blanket in the tank may be lost if the nitrogen blanketing system does not maintain the nitrogen pressure as the tank is pumped down. The nitrogen blanket may also be lost if the tank is opened for inspection. This inspection will be allowed only after the tank atmosphere has been verified to have a flammable vapor (benzene and BuOH) concentration of less than 10% of the LFL. After the inspection, the oxygen concentration will be restored to within requirements.

Frequency One of the initiating event for this accident is the periodic pumpdown of the tank. The draft ITP Addendum gives a frequency of 9 times/yr for this initiating event (Ref. 3). The estimated frequency of pumpdown during the simulant runs would be 30 times/3 month (WME estimate). Therefore, the frequency for this event is $6.8E-4$ /yr (Ref. 3) or $5.7E-5$ /month during periodic pump down.

The frequency for this accident if 4 inspections are performed could be $4.0E-2$ /yr. This assumes that sufficient oxygen leaks during inspection.

Consequences There are no radiological consequences to this event, because no radioactive material is involved. The weld history and the acceptance testing of the Feed Tank indicates that it is not a coded pressure vessel. Therefore, the Feed Tank could fail during a potential benzene deflagration. The release of benzene from the rupture of the Feed Tank would be instantaneous. The toxic chemical hazard methodology (Ref. 20) allows the use of peak 15 minute average concentration for facility, onsite, and offsite comparison with the guidelines. The peak 15 minute average concentration can be used except for those substances that may cause immediate irritation when exposures are short. Benzene does not cause immediate irritation when exposures are short. Exposures of 3000 ppm up to 30 minutes would not cause toxic effects in humans (Ref. 17). The facility, onsite, and offsite concentration of benzene, released during deflagration from the vapor phase and in the entrained liquid, is significantly lower than the amount released during accident 4.2 as shown in Tables 2 and 7 and Appendix A.

The facility benzene concentration from an instantaneous release (1 sec release time) during deflagration is also compared against the benzene exposure during normal operation. The benzene exposure (65.5 mg of benzene) to a facility individual during benzene deflagration would be about 6 times the one working day exposure (10.7 mg of benzene) during normal operation (Appendix A).

The failure of the Feed Tank from a deflagration could impact the nearby Tanks 48, 49, and 50 (Tank Farm facilities) by disabling their ventilation systems. The frequency of $7.9\text{E-}8/\text{hr}$, for the failure of the Feed Tank during deflagration, will be the initiator for disabling the ventilation on Tanks 48, 49, or 50 and it is order of magnitude lower than the lowest initiator frequency of $1.0\text{E-}6/\text{hr}$ in the Tank Farm SAR (Ref. 23).

The calculated fatality frequency of $1.1\text{E-}4/\text{yr}$, from the failure of the Feed Tank, is comparable to the chemical process industry guideline of less than $1.0\text{E-}4/\text{yr}$. This calculation assumes a two-month duration for the simulant runs with benzene in the Feed Tank (Ref. 27), and takes no credit for the absence of an individual at the location of the missile impact.

The pressure from BuOH deflagration is below the benzene deflagration pressure (Ref. 35). The volatility of the BuOH is significantly lower than the benzene. The vapor phase benzene concentration contributes about 99% (Appendix A) to the total amount of the benzene released during the deflagration. Therefore, consequences of the BuOH deflagration are bounded by benzene deflagration consequences.

Mitigation. Mitigation measures for this event include:

- Electrical equipment classified for use in areas where flammable vapors can exist
- Before initial tank filling, purging with nitrogen to maintain oxygen concentration below the minimum concentration for combustion. The oxygen concentration is verified using an oxygen monitor after the purge is completed
- Flame arrestor on the vacuum relief of the Feed Tank and on the conservation vent of the Flush Tank
- Administrative controls to purge the tank if nitrogen pressure is lost
- Nitrogen blanket maintained by a tank pressure regulator
- Monitor oxygen concentration in the Feed Tank every shift

4.6 Benzene Deflagration/Release During the Column Cleaning

Background The purpose of the stripping column is to remove benzene from the filtrate. Oxalic acid is used for column cleaning if there is scaling or pluggage. Benzene could be chemically released

during the column cleaning, assuming that tetraphenylborate is adsorbed on the packing. The stripper column exhaust gases mix with the building exhaust air as shown in Figure 2.14 of Reference 3. If the stripper building ventilation blower is not running, then an interlock closes the valve in the exhaust line between the column and the stack. If the ventilation stops and benzene keeps accumulating in the stack, then an ignition source can cause deflagration of benzene. This accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref 3).

Initiators Benzene concentration in the offgas from a stripping column can exceed the lower flammability limit (LFL) if the building ventilation fails during cleaning and the valve interlock fails. Also needed is a source of ignition. Benzene also can be released to the stripper building through the pressure relief valve.

Frequency The frequency for this event is $1.1\text{E-}4/\text{yr}$ (Ref. 3) or $9.2\text{E-}6/\text{month}$.

Consequences There are no radiological consequences to this event, because no radioactive material is involved. The onsite and offsite concentration of benzene released through the stack, shown in Tables 3 and 4, is below the IDLH and 0.01 IDLH value, respectively. The pressure rise caused by a benzene deflagration in the exhaust stack of the stripper building would not rupture the stack (Ref. 11) and hence, there would not be any damage to outside equipment or personnel. The concentration of benzene released in the stripper building, through the pressure relief valve, is $1.33\text{E}+3 \text{ mg/m}^3$ which also is less than the IDLH value and below the 25 percent of LFL. The ICR for an onsite individual and an individual inside the stripper building is below the Low Hazard criteria in FSAM (Figure 5).

Mitigation Mitigation measures for this event include:

- Administrative controls are in place to require an initial nitrogen purge of the stripper column before cleaning that column with oxalic acid and to require building ventilation be operating to start and to continue oxalic acid cleaning
- Stripper exhaust stack height of 90 ft
- Building ventilation failure alarm
- Valve interlock in the exhaust line between the column and the stack
- No known ignition source (no credit taken).

4.7 Filter Cell Deflagration and Fire

Background The ITP filter and associated piping are located inside a shielded area of the filter building, called the filter cell. This area is air ventilated at about 1,000 cfm by an exhauster through a single stage of HEPA filters. There are eight HEPA filters in this stage to accommodate the volume of ventilation air.

During filtration operations precipitate slurry is pumped from feed tank through the ITP filter at a rate of about 500 gpm. The filtrate goes to a benzene stripping column via a seal tank; the concentrated precipitate slurry returns to feed tank.

The floor of the filter cell contains a sump with a liquid level detector and a sump jet. An interlock to the liquid detector shuts down the precipitate slurry pump if a liquid leak is detected in the sump. This slurry pump also is shut down by another interlock if the cell ventilation fails. If leaks are detected or suspected, the cell has a water spray system to wash any leakage into the sump for jetting back into the process. This benzene deflagration and solids fire accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref. 3).

Initiators A release of precipitate slurry into the filter cell would release benzene vapors into the cell air. Under the most likely conditions, the vapor would remain below the LFL with the ventilation system operating.

A release that occurs in the cell when the ventilation is off releases the benzene present in the slurry at the time of the spill. For small or slow spills, the time to reach the LFL in the cell is very large, allowing time to mitigate the hazards from the spill. However, for a spill of 2,000 gal or more the initial benzene content in the spill brings the vapor concentration close to the LFL (Ref 3). Because of this, filtration operations are terminated (by an interlock) if ventilation stops in the filter cell.

Periodic inspection of each cell will occur prior to each filter and stripper column test. The planned testing and inspection program are judged adequate to prevent solids accumulation in the cell.

There are no known sources of ignition in the filter cell.

Frequency The frequency of this accident is estimated to be $2.2\text{E}-6/\text{yr}$ (Ref. 3) or $1.8\text{E}-7/\text{month}$.

Consequences There would not be an immediate fire hazard from the leak for two reasons. First, the ventilation rate in the cell would dilute the benzene vapors well below the lower flammability limit.

- Second, the leaked slurry would have to dry before becoming combustible.

There are no radiological consequences and the only chemical consequence would be the release of some unburnt KTPB. The amount of KTPB released in this accident would be significantly less than the amount released in accident 4.2.

Mitigation Mitigation measures for this accident include:

- A minimum flow of ventilation air through the filter cell is required for filtration operations. Should this fail, filtration must be shut down.
- The precipitate slurry pump is shut down automatically by an interlock if a liquid leak is detected in the cell sump.
- Periodic inspections of the cell are made to detect any accumulation of solids on the piping connections or floor. Should such be detected, no further filtration is allowed until the cell is adequately cleaned and free of these solids.
- Water sprays in the cell can be used to keep any sump contents wet and prevent drying.

4.8 Feed Solution Spill Due to the Overpressurization of the Transfer Hose

Background The addition of feed solution to Tank 48 is not addressed in this safety evaluation, but the spill of Feed Tank solution due to overpressurization of the transfer hose is evaluated because this is the worst possible accident scenario for the hose failure. Overpressurization of the chemical transfer hose from the Feed Tank to Tank 48 could result in personnel injury from the spilled material or a chemical spill reaching the nearby creek/stream. The chemical transfer hose to be utilized during the transfer has been hydrotested to 180 psig, which is ~150% of what the diaphragm pump is capable of providing (Ref. 10).

Initiators Feed solution can spill if the transfer hose ruptures.

Frequency The probability of a hose rupture is $4.4\text{E-}5$ (Ref. 14), and the frequency of transfer is 5 times/3 months (estimate from WME). Therefore, the frequency for this event is $7.3\text{ E-}5/\text{month}$.

Consequences There are no radiological consequences to this event, because no radioactive material is involved. The worst consequences of this accident would be the release of the entire 12,000 gallons of solution in the Feed Tank. The magnitude of facility,

onsite, and offsite concentrations of chemicals, from a release of this magnitude (12,000 gallons), would be similar to accident 4.2 even though the spill is not confined to the dike. The surface area of the spill could be greater than the diked area used in this accident, but the rate of benzene release from the solution would be controlled by the rate of solution spill. The amount of benzene present in 12,000 gals. of solution is released in 73 sec. (Table 3), and it would take 120 minutes to spill the entire 12,000 gallons outside the dike because of the pump capacity of 100 gpm. Therefore, the surface area used in this calculation is conservative

Mitigation Mitigation measures include:

- Hydrotesting of the transfer hose up to 180 psig.
- Pump capable of providing only 125 psig.
- Local storm sewers diverted to the H-Area Retention Basin prior to transfer.

4.9 Solids Fire in Tank 50

Background Dissolved salts of cesium and potassium are present in most waste tanks. If mixed with a solution of NaTPB, Cs⁺ and K⁺ ions react to form KTPB and CsTPB (XTPB). Feed solution containing NaTPB and insoluble salt of KTPB could be inadvertently transferred to Tank 50. These solids present a fire hazard inside affected waste tanks. This accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref. 3).

Initiators A transfer error in which the transfer hose from feed solution tank is connected to Tank 50. Transfer error must be accompanied by 1) a failure to detect the error before a hazardous quantity is transferred, 2) an ignition source and 3) the requirements for the precipitate (insoluble salts) to dry out in order to arrive at the top event, solids fire in Tank 50.

Frequency The probability of connecting the transfer hose to a wrong tank is 1.0E-2 (Ref. 12), the error not detected is 2.0E-1 (Ref. 12), and the frequency of transfer is 5 times/3 months (estimate from WME). The probability of having an ignition source is 1.0E-1 (Ref. 3) and no credit is taken for the precipitate to dry out (Ref. 3). Therefore, the frequency for this event is 3.2 E-4/month.

Consequences The worst transfer error would be 12,000 gallons containing 0.04 moles/l of NaTPB and approximately 1 wt % of KTPB. KTPB from feed solution tank is non-radioactive, but it could adsorb some amount of radioactivity from the solution in Tank 50. XTPB that forms in Tank 50 will be radioactive.

XTPB floats on the surface of most tanks in which it might form, and some of the XTPB can therefore be expected to be deposited on tank walls where it can dry sufficiently to be ignited. The source term for this accident has already been calculated in the draft ITP Addendum (Ref. 3). It does not include the contribution of radionuclides that could be adsorbed on the non-radioactive precipitate because of lack of data.

The atmospheric source term estimate is believed to be conservative by perhaps one or more orders of magnitude for the following reasons, the effects of which cannot be quantified at this time:

- Ignition might result in only partial combustion. Fires ignited on test plates did not propagate for thin films (approximately 0.1 inch). In thicker films, fire propagation was less than complete and tended to be mainly vertical.
- Smoke from burning XTPB tends to agglomerate into long stringy pieces that adhere to surfaces and will likely not remain dispersed in a low-velocity air stream.

The tank at risk (Tank 50) has an air atmosphere with no provisions for inerting. It would therefore be difficult to extinguish a solids fire, once ignited. In addition, it is likely the exhaust HEPA filter on the affected tank would be rendered ineffective due to solids overloading.

The radiological consequences are contained in Table 5 (Ref. 3). The risk of $3.6\text{E-}6$ rem/yr from this accident to an offsite individual is lower than the Waste Tank Filter Fire accident risk of $3.5\text{E-}5$ rem/yr in the Tank Farm SAR(Ref. 23)

Mitigation Mitigation measures for this event include:

- Administrative and procedural controls on transfer
- No nozzle on Tank 50 (to prevent inadvertent transfer from Feed Tank)

4.10 Corrosive Flush Solution Added to Tank 50 or Tank 48

Background Corrosive solution could be sent to Tank 50 or Tank 48 if sampling of the ITP Flush Tank is not performed to ensure that the flush solution has a pH >12. Transfer of material with pH <12 would violate corrosion controls (Refs 8,9). Normally the flush solution will be transferred to Tank 50 but it could be transferred to Tank 48 depending on the benzene concentration of the flush solution.

Initiators The common initiator for Tank 50 or Tank 48 would be the lack of pH analysis of Flush Tank solution or no corrective measures taken whenever pH of solution is less than 12.

Frequency The Flush Tank solution will be transferred 30 times/3 months (estimate from WME). The probability of not analyzing the solution for pH or for not taking mitigation measures is $1E-2$ (Ref. 12). The estimated frequency of transferring corrosive flush solution to Tank 50 or Tank 48 is $1.0E-1$ /month.

Consequences The flush solution, after neutralization, will be transferred to Tank 50, which contains an average volume of 300,000 gallons at a pH of 14.0. If the maximum volume of 15,000 gallons of oxalic acid (4 weight %), that could be used during the entire filter/stripper test runs and quiet time runs program, is added to Tank 50, then the pH of the solution would decrease from 14.0 to 13.96. In order to maintain a pH of 12 or higher, the minimum volume of waste that must be in Tank 48 or 50 to accept 15,000 gallons of 4 weight % oxalic acid is 18,000 gallons at a pH of 14.0. The surveillance of the tank volume will ensure that both the tanks have a minimum volume of 50,000 gallons (Ref. 28). Therefore, the addition of 15,000 gallons of 4 weight % oxalic acid to Tanks 50 or 48 would have no consequences (corrosion).

Mitigation Mitigation measures for this event include:

- Analyze the contents of Flush Tank before each transfer
- Administrative and procedural controls on transfer

4.11 Deflagration in Filtrate Hold Tank

Background The Filtrate Hold Tanks (FHT) receive filtrate from the stripper columns. The solution usually has a low concentration of benzene. The benzene in the solution was removed by the stripper column. Should the benzene concentration be abnormally high, the vapor is not flammable because the inert blanket gas (nitrogen) does not contain enough oxygen for benzene combustion. If the inert atmosphere is lost and the benzene concentration is abnormally high ($> LFL$), then an ignition source can cause a deflagration of benzene. This accident has already been analyzed in the draft ITP Addendum to the Tank Farm SAR (Ref. 3).

Initiators There are two possible ways that the benzene concentration could become abnormally high. Oxalic acid used to clean the stripper columns could be inadvertently added to a FHT, causing a chemical reaction which would increase the benzene evolution rate. The second way involves inefficient stripper column operation. For example, the flow rate of the stripping gas (nitrogen) could be

insufficient because the setpoint is too low on the controls. (In this case, high benzene concentrations in the filtrate should be detected by the gas chromatographic analysis done on filtrate. Solutions exceeding the benzene limit are recycled through the Feed Tank to the column.)

The inert gas blanket in the FHT may be lost if the nitrogen control valve does not open to maintain the nitrogen pressure as the tank is pumped down. Air could be drawn into the tank through the conservation vent or the overflow line (Ref. 3).

Frequency The frequency, without chemical analysis, is calculated at $3.2\text{E-}5/\text{yr}$ (Ref. 3) or $2.6\text{E-}6/\text{month}$.

Consequences There are no radiological consequences. The FHT is not expected to rupture during the deflagration (Ref.3). However, if it did the amount of benzene (present in the entrained liquid) released would be significantly lower than the amount released during accident 4.2.

Mitigation Vapor deflagrations in the filtrate hold tanks are prevented by eliminating two causes of fire, fuel and oxygen. The filtrate is held in a filtrate hold tank and then transferred to Feed Tank. As long as the stripping column is efficient in removing benzene from the solution, the benzene hazard is mitigated. Should the columns become inefficient for any reason, the inert nitrogen blanket in the filtrate hold tank maintains safe conditions until action is taken, e.g., to restore efficient operation and recycle the filtrate.

Temporary loss of the inert blanket would have no real consequences as long as the columns are stripping benzene as designed. The nitrogen supply system on these tanks is designed to maintain a positive pressure in the tank vapor space. If there are leaks in the tank, nitrogen would leak out rather than air leaking in. As the tanks fill from the stripper columns, tank vapors are forced out of the tank. The likely time for air inleakage would be when the tank contents are pumped out.

An inert atmosphere will be established (in these tanks before any filtration is begun) by purging the tanks with nitrogen. The atmospheres will be verified as inert (i.e., less than 3.6% oxygen by volume) by monitoring the tank exhaust for oxygen content during purging.

After the filtrations begin, the blankets will be continuously maintained with positive nitrogen pressures. Should the pressure in a tank vapor space be lost ($p < 0$ psig), alarms are received. At that time, the purging and verification will be repeated by administrative controls.

4.12 Flush Solution (Containing Oxalic Acid) Inadvertently Added to Feed Tank

Background Flush solution containing about 4 weight % oxalic acid will be used for cleaning the filters and stripper columns. This solution could be inadvertently added to feed tank. Oxalic acid reacts with Na/KTPB to produce benzene. Workers can be exposed to benzene released through the conservation vent on the feed tank.

Initiators The most likely initiator for this event is the inadvertent opening of the valve to the feed tank during cleaning.

Frequency The probability of leaving the valve open is $1.0\text{E-}2$ (Ref. 12) and of the valve error not detected is $2.0\text{E-}1$ (Ref. 12). The probability of not having spectacle flange in the line is $1.0\text{E-}2$ (Ref. 12). The frequency of using the flush solution is 30 times/3month (estimate from WME). Therefore, the frequency for this event is $2.0\text{E-}4/\text{month}$.

Consequences The onsite and offsite concentration of benzene released through the conservation vent shown in Table 2 is below the IDLH and 0.01 IDLH value, respectively. The facility concentration of benzene is below the 0.1 IDLH value as shown in Table 7. The duration of benzene release is below the IDLH guideline (Figure 4) and the ICR value for an onsite individual is below the Low Hazard criteria in FSAM (Figure 5)

Mitigation Mitigation measures for this event include:

- Administrative and procedural controls on transfer
- Spectacle flange in the line

4.13 Transfer of 'Information Only' Simulant Solution and Inhibited Water to Tank 48

The composition of 'Information Only' simulant solution and inhibited water are contained in Tables 10 and 11, respectively. The simulant solution contains salt solution, benzene (up to 300 ppm), TBP (up to 10 gallons) and BuOH (decomposition product of TBP). The inhibited water contains caustic and benzene (up to 50 ppm).

The hazards to Tank 48 from the simulant solution and inhibited water are the flammables benzene, BuOH, and TBP.

Flammables in Simulant Solution

Moles of benzene in simulant solution = $300/1.0 \text{E+}6 \times 12,000 \text{ gal}$

$$\begin{aligned}
 & \times 3.78 \text{ l/gal} \times 0.88 \text{ g/cc} \\
 & \times 1000 \text{ cc/l} \times \text{g mole/78g} \\
 & = 153.5 \text{ g moles}
 \end{aligned}$$

Average temperature in Tank 48 (Ref. 36) = 26°C

Assume all benzene goes into vapor phase in Tank 48.

$$\begin{aligned}
 \text{Volume occupied by 1 mole of benzene at } 26^\circ\text{C} &= 22.4 \text{ l/g mole} \\
 &\times 299.15 \text{ K/273.15 K} \\
 &= 24.5 \text{ l/g mole}
 \end{aligned}$$

$$\begin{aligned}
 \text{Volume occupied by 153.5 g moles of benzene} &= 153.5 \text{ g mole} \\
 &\times 24.5 \text{ l/g mole} \\
 &= 3761.4 \text{ l}
 \end{aligned}$$

$$\begin{aligned}
 \text{Liquid in Tank 48 (Ref. 38)} &= 62.1 \text{ inch} \times 3510 \text{ gal/inch} \\
 &= 217,971 \text{ gal}
 \end{aligned}$$

$$\begin{aligned}
 \text{Vapor volume in Tank 48} &= 1.39 \text{ E}+6 \text{ gal} - 217,971 \text{ gal} \\
 &= 1.17 \text{ E}+6 \text{ gal} \times 3.78 \text{ l/gal} \\
 &= 4.42 \text{ E}+6 \text{ l}
 \end{aligned}$$

$$\begin{aligned}
 \text{Benzene vol. \% in Tank 48} &= 3761.4 \text{ l} / 4.42 \text{ E}+6 \text{ l} \times 100 \\
 &= 8.5 \text{ E}-2\%
 \end{aligned}$$

LFL of Benzene = 1.3% (Volume %)

$$\text{\% of LFL due to Benzene} = 8.5 \text{ E}-2 / 1.3 \times 100 = 6.54\%$$

$$\begin{aligned}
 \text{Moles of TBP in simulant solution} &= 10 \text{ gal} \times 3.78 \text{ l/gal} \times 1000 \text{ cc/l} \\
 &\times 1.0 \text{ g/l} \times \text{g mole/266g} \\
 &= 142.1 \text{ g moles.}
 \end{aligned}$$

1 mole of TBP decomposes to 3 moles of BuOH. Since TBP has negligible pressure at the operating temperatures, it is assumed that all of it has decomposed to BuOH.

$$\begin{aligned}
 \text{Moles of BuOH} &= 142.1 \text{ g moles of TBP} \times \frac{3 \text{ moles of BuOH}}{1 \text{ mole of TBP}} \\
 &= 426.3 \text{ g moles of BuOH}
 \end{aligned}$$

Assume all BuOH goes into vapor phase in Tank 48.

$$\begin{aligned}
 \text{Volume occupied by 426.3 g moles of BuOH} &= 24.5 \text{ l/g mole} \\
 &\times 426.3 \text{ g mole}
 \end{aligned}$$

$$= 10,444.7 \text{ l}$$

$$\text{BuOH vol. \% in Tank 48} = 10,444.7 / 4.42 \text{ E}+6 \times 100 = 2.36 \text{ E-1\%}$$

$$\text{LFL of BuOH} = 1.4\% \text{ (Volume \%)}$$

$$\% \text{ of LFL due to BuOH} = 2.36\text{E-1}/1.4 \times 100 = 16.9\%$$

$$\% \text{ of LFL due to benzene and BuOH} = 23.4\%$$

Flammable in Inhibited Water

$$\begin{aligned} \text{Moles of benzene in Inhibited Water} &= 50/1.0 \text{ E}+6 \\ &\times 5,000 \text{ gal/transfer} \\ &\times 3.78 \text{ l/gal} \times 0.88 \text{ g/cc} \\ &\times 1000 \text{ cc/g} \times \text{g mole}/78\text{g} \\ &= 10.7 \text{ g moles/transfer} \end{aligned}$$

$$\text{Number of transfers} = 4.0$$

$$\begin{aligned} \therefore \text{Total moles of benzene in inhibited water transferred to Tank 48} \\ &= 10.7 \text{ g mole/transfer} \\ &\times 4 \text{ transfer} \\ &= 42.8 \text{ g moles} \end{aligned}$$

Assume all benzene goes into vapor phase in Tank 48.

$$\begin{aligned} \text{Volume occupied by 42.8 g moles of benzene} &= 24.5 \text{ l/g mole} \times 42.8 \text{ g mole} \\ &= 1048.6 \text{ l} \end{aligned}$$

$$\text{Benzene vol \% Tank 48} = 1048.6 / 4.42 \text{ E}+6 \times 100 = 2.4 \text{ E-2\%}$$

$$\% \text{ of LFL due to Benzene} = 2.4 \text{ E-2}/1.3 \times 100 = 1.8\%$$

$$\begin{aligned} \% \text{ of LFL due to simulant solution and inhibited water (4 transfers)} \\ \text{addition} &= 23.4\% + 1.8\% = 25.2\% \end{aligned}$$

The flammable concentration in the vapor phase is 25% of LFL even if all the flammables in the liquid phase from all transfers are instantaneously vaporized into the vapor space of Tank 48 with no ventilation working.

Conditions in Tank 48 Before Transfer

Benzene concentration in Tank 48 (Ref. 37) exhaust
@ ventilation rate of 340 cfm = 1.4 ppm

$$\begin{aligned} \text{Benzene generation in Tank 48} &= 1.4/1.0 \text{ E}+6 \times 340 \text{ cu. feet/min} \\ &= 0.03532 \text{ cu feet/min} \end{aligned}$$

$$= 1.35 \text{ E-2 l/min}$$

$$\begin{aligned} \text{Benzene vol \% in Tank 48} &= 1.35 \text{ E-2 l/min} \times 100 / 4.42 \text{ E+6 l} \\ &= 3.05 \text{ E-7\%/min} \end{aligned}$$

$$\begin{aligned} \% \text{ of LFL due to benzene} &= 3.05 \text{ E-7\%} \times 100 / 1.3\% \text{ min} \\ &= 2.3 \text{ E-5\%/min} \end{aligned}$$

To have benzene concentration equivalent to 1% of LFL, we will need a ventilation loss of 2.3 E+5 min or 91 days. Therefore, benzene generation rate in Tank 48 is insignificant.

Conditions in Tank 48 After the Transfer

The BuOH could further decompose eventually to hydrogen depending on the radiation dose in the tank (Ref. 32).

1 g mole of BuOH could produce 5 g moles of H_2 (Ref. 32)
Assume all the moles of H_2 are produced instantaneously.

$$\begin{aligned} \text{Moles of } \text{H}_2 \text{ produced} &= \frac{5 \text{ g moles of } \text{H}_2}{1 \text{ g mole of BuOH}} \times 426.3 \text{ g moles of BuOH} \\ &= 2131.5 \text{ g moles of } \text{H}_2 \end{aligned}$$

$$\begin{aligned} \text{Volume occupied by 2131.5 g moles of } \text{H}_2 &= 24.5 \text{ l/g moles of } \text{H}_2 \\ 2131.5 \text{ g moles of } \text{H}_2 &= 52,221.7 \text{ l} \end{aligned}$$

$$\begin{aligned} \text{H}_2 \text{ Volume in Tank 48} &= 52,221.7 \text{ l} / 4.42 \text{ E+6 l} \times 100 \\ &= 1.18\% \end{aligned}$$

$$\text{LFL of } \text{H}_2 = 4.1\% \text{ (volume \%)}$$

$$\begin{aligned} \% \text{ of LFL due to Hydrogen} &= \frac{1.18}{4.1} \times 100 \\ &= 28.9 \end{aligned}$$

The contribution of H_2 (produced instantaneously) to LFL is 5.5% higher than the BuOH contribution.

Conclusion

The concentration of flammables in vapor phase from all the solutions ('Information Only' simulant solution and 4 transfers of inhibited water solution) transferred to Tank 48 and the existing concentration of flammables in Tank 48 will be about 25% and 30.5% (assuming all the flammables are released instantaneously) of LFL for BuOH and benzene and benzene and hydrogen, respectively with no ventilation running.

Considering the possibility of benzene/BuOH stratification in the vapor space of Tank 48 and of possible disturbance during the addition, continuously monitor the %LFL value during the transfer and be prepared to stop the transfer should the %LFL increase significantly.

4.14 . Releases During Normal Operations

Stack Releases

The maximum benzene concentration is at 100 meters for a 50 feet high stack release (Ref. 24). The estimated highest maximum 8-hour average ground level benzene concentration is below 0.5 ppm (Ref. 26).

Feed Tank Releases

The filtrate from the FHT is pumped to the Feed Tank 30 times during the Test Runs (Ref. 40). The time to transfer filtrate from the FHT to the Feed Tank is about 246 minutes (35 gpm)(Ref. 27). Therefore, the release of benzene from the Feed Tank will last 246 minutes each time the filtrate is transferred from the FHT to the Feed Tank (Ref. 27). The 8-hour and 1-hour average maximum concentration of benzene (Ref. 24,30) at different locations in the ITP facility are shown in Tables 8 and 9, respectively.

The 1-hour average maximum concentration of benzene at the Filter/Stripper building (241-96H) is 102 times, 3 times, and 0.7 times the short term exposure limit (STEL) (15 minute limit) of 5 ppm during filtrate transfer, pump operation, and thermal cycling, respectively (Table 9). The 1-hour average maximum concentration of benzene is below STEL for distances greater than 30 meters during all normal operations.

The 8-hour average maximum concentration of benzene at different locations in the ITP facility from the Feed Tank are shown in Table 8 (Ref. 24,30). The maximum concentration of benzene is at or below the action level (0.5 ppm) except at building 241-96H where it is 128 times, 10, times, and 1.4 times the action level during the filtrate transfer, pump operation, and thermal cycling, respectively.

During the dissolution of benzene in the salt solution, evaporation of benzene within the Feed Tank will increase the pressure in the tank. Therefore, the benzene vapors will be released in small amounts from the conservation vent over a period of hours until the desired solubility is reached in the Feed Tank. This instantaneous benzene release would occur 3 times every 15 minutes (Ref. 40). The Occupational Safety and Health Administration (OSHA) STEL (5 ppm or 16 mg/m³) guideline is a 15 minute average concentration. Therefore, if the release is averaged over a 15 minute period, the benzene release rate would be 2.36 g/sec. This 15 minute average benzene concentration is about 70% of the concentration during filtrate transfer (3.29 g/sec of benzene) but the instantaneous benzene concentration would be significantly higher.

It is recommended that the access to the building 241-96H be controlled and limited during the entire testing program. The benzene concentrations must be monitored at building 241-96H and at other locations (up to 30 meters from the Feed Tank) to determine the areas where benzene concentration is above the STEL of 5 ppm during filtrate transfer and benzene dissolution. If the benzene concentration is above the STEL during filtrate transfer or during benzene dissolution, then the access to those areas will be controlled.

4.15 Damage to the Permanent ITP and Tank Farm Facilities

Damage to the permanent ITP facilities result from an error in operation (e.g. exceeding the maximum pressure differential across the filter media), modifications to the equipment/facility in order to perform the filter/stripper runs and quiet time runs program, or improper storage of equipment after the completion of testing. The Mott filter is the piece of equipment most vulnerable to damage and is the object of most of the items listed below. There are no onsite or offsite chemical dose consequences from the damage to the permanent ITP facilities.

Operational Errors/Problems:

Siphon potential exists from the Feed Tank through the filter return downcomer. However, the consequences and mitigations of a siphon accident will be similar to a spill as discussed in accidents 4.1 and/or 4.2. There are no other downcomers in the Feed Tank and there are no downcomers in the Flush Tank.

The Feed Tank and the FHT could be damaged during the runs as indicated in accidents 4.5 and 4.11, respectively.

Operational errors, that could result in damage to the permanent ITP facilities include:

- Exceeding the design pressure drop across the filter media could rupture the filter tubes or cause irreversible plugging of the filter media. Tube rupture could occur with either slurry or water; complete media plugging is possible with slurry or unfiltered well water. Either tube rupture or media plugging could occur as the result of accidentally over-restricting the tube side flow downstream of the filter or incorrect operation of the pump used to feed the filter.
- Water hammer could occur at startup.

These types of errors are unlikely because of the following controls:

- Controls/interlocks on the permanent facility and the temporary facilities have been functionally checked. These include an administrative control to ramp the filter feed pump up to the desired flow rate whenever it is started; interlocks to stop the filter feed pump on low precipitate flow, on high precipitate pressure and when filter isolation valves are closed; and an automatic control which delays the opening of the filter inlet valve when filter feed pump is started.
- The variable speed drive for the permanent filter feed pumps will be used to operate the temporary filter feed pump. This will allow use of some process interlocks in place to protect the filter.
- The pump will be started at low speed to reduce the potential for water hammer.

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APPENDIX A

This appendix contains the chemical consequences for accident 4.5, Benzene/BuOH Deflagration in the Feed Tank. The chemical consequences for other accidents are contained in Reference A7 of this appendix.

Chemical Consequences of Potential Benzene Deflagration in the Feed Tank

The Feed Tank is nitrogen-inerted before benzene is introduced. There is not enough oxygen for benzene deflagration during the dissolution of benzene in the liquid phase (salt solution). There is a possibility of air in-leakage, if the nitrogen blanket system fails, during filtration. Therefore, benzene deflagration is possible during or after the filtration is started.

The chemical consequences of the benzene deflagration for the worst case are:

1. Total Benzene in Feed Tank (Ref. A1) = 20.0 gal
= 20.0 gal x 3.78 l/gal
= 75.6 liters
2. Density of Benzene at 20°C (Ref. A2) = 0.88 g/cc
3. Feed Tank Liquid Volume (Ref. A1) = 12,000 gal
4. Concentration of benzene in the liquid phase before filtration (Ref. A1) = 173 mg/l
5. Benzene in liquid phase = 12,000 gal x 3.78 l/gal x 173 mg/l x g/1000 mg x 1/880 g
= 8.92 liters
6. Minimum liquid level in the Feed Tank (Ref. A1) = 1500 gal
7. Maximum possible air in-leakage = 12,000 - 1500 gal
= 10,500 gal
8. The concentration of benzene in air at stoichiometric conditions (Ref. A3) = 2.7 vol %
9. Volume of benzene used in the deflagration = 10,500 (0.027) gal
= 283.5 gal
- 10 Volume of 1 mole of ideal gas at 273K and 1 atm (Ref. A4) = 22.4 liters

- 1 1 Volume of 1 mole of ideal gas at 25°C = 22.4 l x 298/273
(Ref. A1) and 1 atm = 24.5 liters
- 1 2 Molecular weight of benzene (Ref. A2) = 78 g/g mole
- 1 3 Benzene used in the deflagration = 283.5 gal x 3.78 l/gal
g mole/24.5 l x 78 g/g mole x
l/880 g
= 3.88 liters
- 1 4 Total Benzene used in the deflagration
and present in the liquid phase = 8.92 + 3.88
= 12.8 liters
- 1 5 Benzene available for release in the
vapor phase during deflagration = 75.6 - 12.8
= 62.8 liters
- 1 6 Respirable fraction (≤ 10 micron) of
liquid phase released during deflagration
(Ref. A5) = 43.1 kg
- 1 7 The density of the liquid phase is
assumed to be 1.0 kg/l
- 1 8 Benzene released during deflagration
from the liquid phase = 43.1 kg x 1.0 kg/l x 173 mg/l
x g/1000 mg x l/880g
= 0.008 liters
- 1 9 Total benzene released during
deflagration = 62.8 + 0.008 liters
= 62.808 liters

The release of benzene from the rupture of the simulant Feed Tank would be instantaneous. The toxic chemical hazard methodology (Ref. A6) allows the use of peak 15 minute average concentration for facility, onsite, and offsite comparison with the guidelines.

- 2 0 Peak 15 minute average benzene
release rate = 62.808 l x 880 g/l x 1/900 sec.

$$\begin{aligned} & \times 1000 \text{ mg/g} \\ & = 6.1 \text{ E}+4 \text{ mg/sec.} \end{aligned}$$

2 1 The benzene release rate for the entire
Feed Tank Spill Accident (Accident 4.2)
(Ref. A7) $= 1.23 \text{ E}+6 \text{ mg/sec}$

2 2 The ratio of release rate from the Peak
15 minute average during deflagration
and entire Feed Tank spill accident $= 6.1 \text{ E}+4 / 1.23 \text{ E}+6$
 $= 0.05$

The facility (10 meter), onsite (100 meter), and offsite benzene concentration from the Entire Feed Tank Spill/Fire accident are $6.28 \text{ E}+3$, $5.35 \text{ E}+3$, and $8.63 \text{ E}+0 \text{ mg/m}^3$, respectively (Table 7 and 2).

2 3 Facility benzene concentration during
deflagration $= 6.28 \text{ E}+3 \text{ mg/m}^3 \times 0.05$
 $= 3.14 \text{ E}+2 \text{ mg/m}^3$

2 4 Onsite benzene concentration during
deflagration $= 5.35 \text{ E}+3 \text{ mg/m}^3 \times 0.05$
 $= 2.67 \text{ E}+2 \text{ mg/m}^3$

2 5 Offsite benzene concentration during
deflagration $= 8.63 \text{ E}+0 \text{ mg/m}^3 \times 0.05$
 $= 4.31 \text{ E}-1 \text{ mg/m}^3$

The onsite and offsite increase in lifetime Incremental Cancer Risk (ICR) values from benzene for the Entire Feed Tank Spill/Fire accident are $6.0 \text{ E}-5$ and $9.6 \text{ E}-8$, respectively (Table 6).

2 6 Onsite ICR from benzene $= 6.0 \text{ E}-5 \times 0.05$
 $= 3.0 \text{ E}-6$

2 7 Offsite ICR from benzene $= 9.6 \text{ E}-8 \times 0.05$
 $= 4.8 \text{ E}-9$

The facility benzene concentration from an instantaneous release during deflagration is also compared against the benzene exposure during normal operation.

28 Action limit for benzene (Ref. A8) = 1.60 mg/m^3 (0.5 ppm)

29 The average breathing rate for adults (Ref. A6) = $20 \text{ m}^3/\text{day}$

30 Working day = $8 \text{ hr}/24 \text{ hr/day}$
= $1/3 \text{ day}$

31 Exposure per working day during normal operation = $1.60 \text{ mg/m}^3 \times 20 \text{ m}^3/\text{day} \times 1/3 \text{ day}$
= 10.7 mg

32 Facility benzene concentration for 1 sec release = $3.14\text{E}+2 \text{ mg/m}^3 \times 900$
= $2.83\text{E}+5 \text{ mg/m}^3$

33 Volume inhaled in 1 sec = $20 \text{ m}^3/\text{day} \times \text{day}/8.64\text{E}+4 \text{ sec}$
= $2.31\text{E}-4 \text{ m}^3$

34 Exposure during deflagration = $2.83\text{E}+5 \text{ mg/m}^3 \times 2.31\text{E}-4 \text{ m}^3$
= $6.55\text{E}+1 \text{ mg}$

The benzene exposure to a facility individual during benzene deflagration would be about 6 times the one working day exposure during normal operation.

The facility, onsite and offsite benzene concentrations and onsite and offsite ICRs are significantly below the bounding consequences of the Entire Feed Tank Spill/Fire accident.

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TABLE 1. COMPOSITION OF SIMULANT SOLUTION (REF. 7)

<u>Component</u>	<u>Concentration</u>	<u>(Nominal)</u>	<u>Quantity</u>
Salt Solution	Total Na ⁺	4.81 M	7500 gal
	NaOH	2.57 M	
	NaNO ₃	1.35 M	
	Na ₂ SO ₄	0.015 M	
	NaNO ₂	0.39 M	
	Na ₂ CO ₃	0.01 M	
	NaAlO ₂	0.45 M	
	KOH	0.036 M	
	KNO ₃	0.16 M	
STPB	Na ⁺	0.55 M	4090 gal
Benzene			20 gal
ST	ST solids	125 g/L	140 gal
TBP			60 gal

NOTES:

- (1) Initial salt concentration was specified to yield a 4.5 molar salt solution after the addition of the ST slurry and the STPB solution.
- (2) KOH and KNO₃ added as a source of potassium for precipitate (KTPB) formation.

TABLE 2. CONCENTRATION OF VOLATILE CHEMICALS DURING VARIOUS ACCIDENTS

Accident Number	<u>Onsite Concentration^a, mg/m³</u>					<u>Offsite Concentration^b, mg/m³</u>				
	Methanol* 3.16E+4 (25,000 ppm)	Isopropanol* 3.00E+4 (12,000 ppm)	Benzene* 9.57E+3 (3,000 ppm)	TBP* 1.4E+3 125 ppm	BuOH* 2.4E+4 8000 ppm	Methanol** 3.16E+2	Isopropanol* 2.53E+2	Benzene* 9.57E+1	TBP* 1.4E+1	BuOH* 2.4E+2
4.1	9.79E-1	1.50E+0	2.25E+2 ^d 5.66E+1 ^e 1.99E+1 ^f	4.83E-3 ^h 8.09E-2 ^g		1.58E-3 3.21E-2 ^f	2.41E-3 4.90E-2 ^f	3.63E-1 ^d 9.13E-2 ^e 8.28E-1 ^g	7.79E-6 ^h 1.30E-4 ^g	
4.2	2.00E+0	1.45E+1	5.35E+3	3.09E+0	8.05E+2	3.23E-3	2.33E-2	8.63E+0	4.99E-3	1.30E+0
4.4			8.30E-1 5.31E+3 ^c					4.18E-2		
4.5			2.67E+2					4.31E-1		
4.6			2.08E-1 1.33E+3 ^c					1.06E-2		
4.12			2.63E+2					4.24E-1		

^a Onsite: 100 meter from release point; highest 2-hr. X/Q (worst case)

^b Offsite: 11.9 km to the site boundary; highest 2-hr. X/Q (worst case)

^c Concentration inside the stripper building

^d Benzene present in STPB solution

^e Benzene in 5 gal. bottles; ^f 55 gal. drum spill; ^g 5 gal bottle spill; ^h TBP in 5 gal bottles

* Immediately Dangerous to Life and Health (IDLH) value for Low Hazard Facility

** 0.01 IDLH value for General Use Facility

TABLE 3. RELEASE TIME OF THE CHEMICALS DURING VARIOUS ACCIDENTS

<u>Accident Number</u>	<u>Methanol</u>		<u>Isopropanol</u>		<u>Benzene</u>		<u>TBP</u>		<u>BuOH</u>	
	<u>Amount Released gm</u>	<u>Release Time sec</u>	<u>Amount Released gm</u>	<u>Release Time sec</u>	<u>Amount Released gm</u>	<u>Release Time sec</u>	<u>Amount Released gm</u>	<u>Release Time sec</u>	<u>Amount Released gm</u>	<u>Release Time sec</u>
4.1	74	328	74	215	1829 ^a	141 ^a	1.13E+3 ^d	1.02E+6 ^d		
	4,927 ^c	1,078 ^c	4,927 ^c	705 ^c	61 ^b 16,632 ^c	2 ^b 141 ^c	1.89E+4 ^c	1.02E+6 ^c		
4.2	12,536 ^e	2.9E 4 ^e	12,498 ^e	3,955 ^e	85,600 ^e	73 ^e	2.27E+5 ^e	3.36E+4 ^e	1.86E+5 ^e	1.06E+3 ^e
4.4					85,600 ^e	1.1E+4 ^e				
4.12					22,700	375				

- a pure benzene
b benzene in STPB
c 5 gal. bottle spill
d 0.3 gal.
e liquid phase only

**TABLE 4. CONCENTRATION OF NON-VOLATILE CHEMICALS
DURING VARIOUS ACCIDENTS**

Accident Number	<u>Onsite Concentration^a, mg/m³</u>				<u>Offsite Concentration^b, mg/m³</u>			
	ST n/a	STPB n/a	NaOH 2.0E+2*	Oxalic Acid 5.0E+2*	ST n/a	STPB n/a	NaOH 2.0E+0**	Oxalic Acid 5.0E+0**
4.1	8.13E-3 2.70E-1 ^c	6.93E-1	9.20E-3	3.04E-1	1.31E-5 4.34E-4 ^c	1.12E-3	1.48E-5	4.91E-4
4.2	1.38E+0	6.19E+1			2.23E-3	9.98E-2		

^aOnsite: 100 meter from release point; highest 2-hr. X/Q (worst case)

^bOffsite: 11.9 km to the site boundary; highest 2-hr X/Q (worst case)

^c55 gal. drum spill

* Immediately Dangerous to Life and Health (IDLH) value for Low Hazard facility.

** 0.01 (IDLH) for General Use facility.

TABLE 5. RADIOLOGICAL CONSEQUENCES OF VARIOUS ACCIDENTS

<u>Accident Number</u>	<u>Onsite Consequences</u>	<u>Offsite Consequences^a</u>
	<u>50-Year Dose, Max. Individual, EDE, rem</u>	<u>50-Year Dose, Max. Individual, EDE, rem</u>
4.9	5.4E+0 ^b	8.9E-3

^a offsite: 11.9 km to the site boundary; highest 2-hr X/Q (worst case)

^b onsite: 100 meter from release point; highest 2-hr X/Q (worst case)

TABLE 6. ICR FROM BENZENE FOR AN ONSITE AND OFFSITE INDIVIDUAL

<u>Accident Number</u>	<u>Onsite</u>		<u>Offsite</u>	
	Concentration mg/m ³	ICR	Concentration	ICR
4.1	2.25E+2 ^a	2.5E-6	3.63E-1 ^a	4.0E-9
	5.13E+2 ^b	5.7E-6	8.28E-1 ^b	9.2E-9
	5.66E+1 ^d	6.3E-7 ^d	9.13E-2 ^d	1.0E-9 ^d
4.2	5.35E+3	6.0E-5	8.63E+0	9.6E-8
4.4	3.60E-1	4.0E-9	1.81E-2	2.0E-10
	2.30E+3 ^c	2.5E-5		
4.5	2.67E+2	3.0E-6	4.31E-1	4.8E-9
4.6	2.08E-1	2.3E-9	1.06E-2	1.2E-10
	1.33E+3 ^c	1.5E-5		
4.12	2.63E+2	2.9E-6	4.24E-1	4.8E-9

- ^a Benzene present in the STPB solution
^b Spill of a entire 5 gal. bottle of Benzene
^c Inside the stripper building
^d Benzene in 5 gal. bottle

**TABLE 7. FACILITY CONCENTRATION^a OF VOLATILE CHEMICALS
DURING VARIOUS ACCIDENTS**

	<u>Methanol</u> *	<u>Isopropanol</u> *	<u>Benzene</u> *	<u>IBP</u>	<u>BuOH</u>
	3.16 E+4 mg/m ³ (25,000 ppm)	3.00 E+4 mg/m ³ (12,000 ppm)	9.57 E+3 mg/m ³ (3000 ppm)	1.40E+3 mg/m ³ (125 ppm)	2.4E+4 mg/m ³ (8000 ppm)
<u>Accident Number</u>					
4.1	4.55E-1 3.26E+2 ^b	7.25E+1 5.28E+2 ^b	4.80E+1 ^d 1.59E+3 ^f 1.75E+2 ^e	1.1E+0	
4.2	2.78E+1	3.75E+1	6.28E+3	1.1E+1	2.8E+3
4.5			3.14E+2		
4.12			7.37E+1 ^c		

^a 10 meters from release point

^b 55 gal. drum spill

^c 20 meters from release point

^d Benzene in STPB solution

^e Benzene in 5 gal. bottle

^f 5 gal. bottle spill

* Immediately Dangerous to Life and Health (IDLH) value (equivalent to Low Hazard Facility)

TABLE 8. MAXIMUM CONCENTRATIONS IN PARTS PER MILLION (PPM) - 8 HR. AVERAGING

	<u>241-96H^a</u>	<u>Benzene (0.5 ppm)* Surrounding Area^b</u>	<u>241-96H^a</u>	<u>BuOH (50 ppm)** Surrounding Area^b</u>
Filtrate Transfer Release (Pump out)	64	0.5	9.5	0.04
During pump operation	5	0.05	0.8	0.008
Thermal Cycling 24 hrs.	0.7	0.01	0.1	0.003

* OSHA Action Level

** OSHA TWA

a Worst case estimate based on interaction of Feed Tank plume with Building 241-96H (filter-stripper building) during southeasterly winds.

b Highest values from receptor grids located beyond the immediate influence of building 241-96H (greater than 30 meters downwind of the Feed Tank).

TABLE 9: MAXIMUM CONCENTRATIONS IN PARTS PER MILLION (PPM) - 1-HR AVERAGING

	<u>241-96H^a</u>	<u>Benzene (0.5 ppm)* Surrounding Area^b</u>	<u>241-96H^a</u>	<u>BuOH (50 ppm)** Surrounding Area^b</u>
Filtrate Transfer Release (Pump out)	511	3.9	73	0.5
During pump operation	16	0.1	2.6	0.02
Thermal Cycling 24 hrs	3.7	0.02	0.7	0.004

^a Worst case estimate based on interaction of Feed Tank plume with Building 241-96H (filter/stripper building) during southeasterly winds.

^b Highest values from receptor grids located beyond the immediate influence of Building 241-96H (greater than 30 meters downwind of the Feed Tank)

TABLE 10: COMPOSITION OF INFORMATION ONLY SIMULANT SOLUTION

Salt Solution (Nominal Concentration of constituents)	2.5 - 3.0M	9,000 gallons
NaOH	2.57M	
NaNO ₃	1.35M	
Na ₂ SO ₄	0.015M	
Na NO ₂	0.39M	
Na ₂ CO ₃	0.01M	
NaAlO ₂	0.45M	
KOH	0.036M	
KNO ₃	0.16M	
Benzene		≤300 ppm (per TA)
TBP and/or BuOH, DBP, MBP		≤10 gallons

TABLE 11: COMPOSITION OF INHIBITED WATER

Inhibited Water (caustic 0.1M)	5000 gal
Benzene	≤ 50 ppm

Figure 1. ITP Process Flow During Radioactive Processing

LAYOUT OF TEMPORARY
AND PERMANENT FACILITIES

Figure 2. ITP Temporary Simulant Run Facility

FIG. 3 ACCIDENT 4.2, ENTIRE TANK SPILL

- 1. Chemical Spills
 - 1a. Benzene in STPB
 - 1b. Spill of 5 gal Benzene Bottle
 - 1c. Benzene in 5 gal Bottles
- 2. Feed Tank Spill/Fire
- 3. Benzene Release into Stripper Building
- 4. Flush Solution Inadvertently Added to Feed Tank

Figure 4. Onsite Benzene Concentration for Potential Accidents

1. Chemical Spills
 - 1a. Benzene in STPB
 - 1b. Spill of 5 gal Benzene Bottle
 - 1c. Benzene in 5 gal Bottles
2. Feed Tank Spill/Fire
3. Benzene Release into Stripper Building
4. Benzene Deflagration Release During Column Cleaning
 - 4a. Release Through Stack
 - 4b. Release into Stripper Building
5. Flush Solution Inadvertently Added to Feed Tank
6. Benzene/Butanol Deflagration in Feed Tank

Figure 5. Onsite ICR from Benzene for Potential Accidents

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