**Department of Energy**
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802
JAN 28 1997

The Honorable John T. Conway
Chairman, Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W., Suite 700
Washington, D.C. 20024

Dear Mr. Chairman:

SUBJECT: Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 96-1 Deliverable - Safety Strategy for Tanks 48, 49, and 50 Deflagrations

Enclosed is the subject safety strategy document which satisfies a deliverable (Commitment #2, Milestone #5.2.1-2) for the DNFSB Recommendation 96-1 Implementation Plan.

This safety strategy document summarizes the basis for selecting the safety strategy for prevention and mitigation of deflagrations in Tanks 48, 49, and 50. This document identifies engineered systems, administrative controls, and operating limits being put in place to minimize the possibility for and consequences of postulated deflagrations. Additionally, this document identifies key assumptions which must be resolved to support the safety strategy selected. These assumptions will be resolved in developing the Safety Analysis Report and Technical Safety Requirements for the In-Tank Precipitation Facility.

The U.S. Department of Energy, Savannah River Operations Office, has completed the actions for the above deliverable (Milestone #5.2.1-2) and proposes its closure. Copies of this deliverable have been provided and discussed with your staff.

If you have any questions, please contact me or W. F. Spader at extension 208-7409.

Sincerely,

A. Lee Watkins
Assistant Manager
for High Level Waste

ED:TCT:bjt

PC-97-0025

Enclosure
Safety Strategy - DNFSB Recommendation 96-1 Implementation Plan

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Revision 0
Keywords:
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Safety Systems
Safety Basis Upgrade
Retention:
Lifetime

# ITP Safety Strategy for Tanks 48, 49, and 50 Deflagrations (U)

January, 1997

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## 1.0 Executive Summary

Paramount to the safety strategy presented in this document, deflagrations in the In-Tank Precipitation (ITP) facility waste tanks are unacceptable events and must be prevented. Due to unexpectedly high releases of benzene vapors during startup program slurry pump operation, the current mode of operation and associated protective systems for Tanks 48 and 49 are no longer conservative. Planned process verification tests were placed on hold pending resolution of the benzene chemistry concerns identified during the startup program pump operations. As a result of the uncertainty in the benzene chemistry for Tanks 48, 49, and 50, a program was developed to further the scientific understanding of the mechanisms and parameters affecting benzene generation from the breakdown of sodium tetraphenylborate (NaTPB) and its intermediate products, its retention in the liquid slurry, and its release to the tank vapor space. Due to the long duration of the chemistry program and to prevent overscoping the program, a parallel activity was begun to identify potential changes in the ITP safety strategy and identify equipment upgrades/administrative controls which would minimize the need for more extensive chemistry information. This parallel activity has resulted in a proposal for additional equipment modifications and administrative controls for Tanks 48, 49, and 50 (See Table 1).

Actions were taken to review all potential modes of operation for Tanks 48, 49, and 50 with respect to potential normal, abnormal and accident conditions. The review included impacts for each mode of operation on the safety of the offsite public, co-located and facility workers, and plant equipment, as well as the impact on the scope of facility upgrades and retraining of facility personnel. Of particular importance was any detrimental impact on contamination control and industrial health due to proposed modes of operation which are different than current facility design and operation. The results of this review determined that, for Tanks 48 and 49, four separate modes of operation were required to address all potential events/conditions. These modes included normal operations (oxygen control, with fuel control as defense-in-depth), standby (oxygen control only), minor maintenance (oxygen control and fuel control), and major maintenance (fuel control only). Only standby mode resulted in an operational philosophy which was different from the current facility practice, in that the tanks will be taken to a slightly positive pressure in lieu of the current negative pressure operation. This action is necessary to prevent oxygen inleakage with subsequent development of a flammable vapor within the tank. The desire to maintain oxygen control with fuel control as defense-in-depth for all modes was not achievable due to the problems associated with tank top contamination and operator safety and due to the extensive plant modifications associated with assuring safety under all potential events/conditions.

Tank 50 was determined to be safe under the current negative pressure, fuel control mode of operation based on additional administrative controls to be placed on the feed to this tank, on temperature of the tank liquid, on inventory control, and on the low benzene generation rate under these conditions. The chemistry program will be relied on to validate the assumptions used in this decision (assumptions 1,2,3,16,17,18).

To assure the safety of Tanks 48, 49, and 50 under all conditions, a number of modifications and new administrative controls on existing equipment and operator response are required. These include installation of a qualified backup nitrogen supply for Tanks 48 and 49 (previously in progress), interlocks to isolate tank ventilation and normal nitrogen supply and initiate backup nitrogen based on several key process parameters, including seismic event (increased scope), interlocks to stop tank agitation on high flammable vapor concentration (new), administrative controls on tank liquid temperature (new), tank chemistry (new), benzene and hydrogen depletion from the tank liquid (new), and abnormal/emergency response actions (increased scope). Additional administrative controls were placed on tank level as mitigative measures (new).

Although the safety strategy is based on engineered features and administrative controls which will prevent and/or mitigate potential adverse consequences, some chemistry information is necessary to validate the design inputs and safety assumptions. The chemistry program has been structured to provide validation of the key assumptions in support of authorization basis upgrade activities and so as not to adversely impact the design and installation activities for the equipment upgrades (assumptions 1,2,3). However, risk does exist that the chemistry program will uncover information regarding the generation, retention or release of benzene which could require Authorization Basis rework or additional plant modifications.

In addition to the chemistry program interface, several key assumptions regarding current facility design could adversely impact implementation of the revised safety strategy. This includes proof of an adequately mixed vapor space under negative pressure operation (assumption 9), ability to control tank inleakage points (assumption 10), and the ability to NPH qualify tank inleakage (assumption 11). Adequate mixing of the vapor space is being defined using data from previous testing, but new data may be required to support this assumption (assumption 9). Planned modifications and administrative controls will minimize the risk for these design areas.

## 2.0 Background

The ITP facility consists of a processing vessel (Tank 48), crossflow filters, benzene strippers, filtrate hold tanks, a washed precipitate storage tank (Tank 49), a wash water hold tank (Tank 50), associated transfer lines, and other support equipment. In Tank 48, the cesium is precipitated along with potassium. The decontaminated solution is removed by filtration, stripped of benzene, and transferred to Saltsone. The concentrated precipitate is then washed of salts in Tank 48 using the filters. The wash water is stripped of benzene and stored in Tank 50, along with spent washwater from the Late Wash Facility, for use in subsequent batches. The washed precipitate is stored in Tank 49 until sent to Late Wash. This report will address the issues and resolutions related to control of explosive mixtures in Tanks 48, 49, and 50. In particular, it will address the engineered features, administrative controls, and operating strategy relating to the generation, retention, and release of flammable vapors in these tanks.

The ITP facility initiated radioactive operations in September 1995 with the addition of 130,000 gallons of salt solution and 37,300 gallons of NaTPB to the heel of precipitate in Tank 48 that remained from a full scale demonstration in 1983. During October, the first of three pump tests was conducted in which the effect of tank mixing was determined. This test was characterized by a nearly constant benzene release from the liquid phase to the vapor phase that maintained the vapor space concentration at nearly 60 ppm during pump operations. Following the completion of the first pump run on October 12, 1995, the tank remained quiescent until October 20, 1995.

Filtration began on October 20, 1995 and continued until October 25 producing 140,000 gallons of filtrate. Filtration was conducted at a nearly constant temperature of 39°C. Filtration was followed by the second pump run starting October 26. The benzene concentration in the vapor space was higher than expected, but well below the Operational Safety Requirement (OSR) limit of 3250 ppm (indicated). A water addition was made without an expected increase in benzene vapor concentration. A second filtration step was conducted producing 160,000 gallons of filtrate and bringing the liquid level in Tank 48 down to 160,000 gallons. The third pump run on November 10, which was designed to be conducted at higher temperatures to support oxygen control testing, resulted in heating the tank to 52 °C. Again, the benzene vapor concentration was higher than expected but still below the OSR limit. The tank was quiescent during ventilation tests and had cooled to 30 °C by December 1, 1995.

On December 1, 1995, all four slurry pumps were operated at maximum speed (1180 rpm) for about 3.5 hours to prepare the tank for sampling. Pump operation was then halted due to the observed high benzene readings (2,000 ppm) in the tank vapor space, well before the OSR limit was approached. Sampling and mixing requirements were satisfactorily met. Data from Tank 48 instrumentation and tank sample analyses indicated that NaTPB decomposition had occurred. Efforts began to remove the benzene that had accumulated. A Justification for Continued Operation (JCO) (Ref. 12) was written to incorporate additional controls on the rate of benzene release that would be allowed during pump operation. A series of single pump runs was conducted under the JCO to deplete the benzene from the tank between December 8, 1995 and January 3, 1996. From January 3 to March 5, 1996, the tank was quiescent. During this period, an alternate nitrogen system was installed, and the JCO was revised to credit nitrogen inerting and to provide less restrictive pump operating limits.

On March 5, 1996, one slurry pump was operated at low (600 rpm) speed. A high rate of benzene release was immediately seen in the tank vapor space and pump operation was terminated after 14 minutes. The data indicated periods of non-uniform distribution of benzene in the tank vapor space. Starting on March 8, periodic pump operations were resumed in a conservative, controlled manner in continued efforts to deplete benzene from the tank. Initial operations employed only one slurry pump. As benzene release rates decreased, additional pumps were started. By April 25, 1996, all four pumps were operating at the maximum speed of 1,180 rpm. From November 5, 1995 to April 22, 1996, an estimated 8,500 kg of benzene were removed from Tank 48. Since April, 1996, Tank 48 has essentially been depleted of benzene as indicated by the very small releases observed even with operation of all four pumps.

Savannah River had planned to proceed with a series of Process Verification Tests (PVTs) in Tank 48 designed to increase the level of understanding of NaTPB chemistry and benzene release mechanisms. The first such test, PVT-1, was completed and involved addition of a small amount of NaTPB to reprecipitate soluble cesium, filter operation to reduce the volume of liquid in Tank 48, and filter cleaning verification. Key objectives of this test included: verification of the effectiveness of cesium recovery (successful), validation of benzene generation rates in Tanks 48 and 50 (not possible with the small amount of NaTPB added, but did validate analysis method for intermediates), and verification of the impact of oxalic acid addition on benzene generation (completed). The next test, PVT-2, was to include the addition of significant quantities of new waste and NaTPB to Tank 48.

Prior to the initiation of PVT-1, the Department of Energy recommended delay of future process verification testing which required transfer of waste into Tank 48 until an improved understanding of the mechanisms of formation of benzene and the amount and rate of its release (Ref. 7). In response, WSRC deferred the conduct of PVT-2 until such time as an improved understanding of NaTPB chemistry could be achieved and the appropriate modifications to facility hardware and administrative controls are completed.

The implementation plan (Ref. 9) for resolution of Recommendation 96-1 (Ref. 1) describes those activities to be completed in resolving the issue of generation, retention, and release of flammable vapors in Tanks 48, 49, and 50. The following actions are being taken as part of this resolution approach.

1) Review the existing administrative controls and engineered systems for preventing and/or mitigating tank deflagrations, based on the current understanding of Tetraphenylborate (TPB) chemistry, and adjust the philosophy and controls to minimize the reliance on extensive understanding of the factors which may impact this chemistry.

2) Develop a greater understanding of the reactions leading to the generation of benzene in Tanks 48, 49, and 50 to ensure that the controls for preventing and/or mitigating deflagrations are adequate,

3) Develop a greater understanding of the mechanisms leading to the retention of benzene in Tanks 48, 49, and 50 to ensure that the controls for preventing and/or mitigating deflagrations are adequate, and

4) Develop a greater understanding of mechanisms involved with the release of benzene in the Tanks 48, 49, and 50 to ensure that the controls for preventing and/or mitigating deflagrations are adequate.

The safety strategy and its implementation, as discussed in this report, are predicated on the assumption that adequate controls can be defined based on a limited understanding of the factors which may impact TPB chemistry (assumptions 1,2,3). It is recognized that critical administrative controls and certain modes of operation will require additional information on TPB chemistry, and that the establishment of this safety strategy and designation of engineered features is being performed at risk (financial and schedule only). These risks are directly related to the assumptions described in section 6.0 of this report.

2.1 Summary of Previous Safety Strategies

The ITP facility was originally part of the H-area tank farm and, as such, was operated entirely as a negative pressure, air-based system. When the tanks were converted to the present process, the mode of operations was retained. This was based on a precept of sufficient understanding of the chemistry of the process to be able to define the minimum flowrate through the tanks to maintain the vapor space less than 25% (indicated) of the Lower Flammable Limit (LFL) for benzene. This was subsequently changed to address the impact of hydrogen on the LFL for benzene, and the concept of Composite Lower Flammable Limit (CLFL) control was implemented. The safety of the facility was assured by providing engineered features and administrative controls to maintain at least three days to CLFL upon loss of ventilation. Emergency Purge Ventilation Equipment was added as an operator response to address continued safety during NPH events. As recently as November, 1995, the CLFL safety strategy was the primary safety strategy (Ref. 12). A nitrogen purge system existed, but was not credited within the authorization basis (AB) documents.

During the testing in late 1995, as discussed in section 2.0 of this report, it was recognized that benzene releases were greater than could be supported by the CLFL safety philosophy. A transition was then made toward crediting oxygen control within the AB documents. A temporary, alternate nitrogen system was installed in February, 1996 to provide redundancy to the existing nitrogen system. CLFL control was still considered the primary safety strategy, with oxygen control as the backup.

Following plant testing in March, 1996, the large benzene release rate observed during pump operation resulted in a further transition from CLFL control to oxygen control as the primary safety strategy in Tank 48. A project to install a new, safety grade nitrogen system was initiated for Tanks 48 and 49 to implement this change in philosophy. However, significant credit was still given to CLFL control.

Based on the concerns with the generation, retention, and release of benzene, and to resolve anomalies discovered during laboratory and plant chemistry testing, a safety strategy is needed which addresses uncertainties in the facility chemistry and provides appropriate defense-in-depth to prevent/mitigate tank vapor space deflagrations under all potential modes of operation. The following sections discuss details of the proposal for a safety strategy which will accomplish this goal.

## 3.0 Resolution Pathforward

As part of the resolution of the issue with control of flammable vapors, the ITP safety basis will address both preventive and mitigative functions. Examples of potential safety controls and systems for prevention and/or mitigation of deflagration events which have been considered are as follows:

> The preventive function may include the establishment of inerting control and monitoring of oxygen concentration in the vapor space; establishment of appropriate interlocks to isolate and pressurize the tanks to preclude oxygen inleakage; tank ventilation systems to remove hydrogen and benzene vapors; monitoring for flammable vapor concentrations in the vapor space and actions to deenergize slurry pumps and stop tank transfers; and minimization of spark sources internal to the tank vapor space.
>
> The mitigative functions may include periodic reduction of liquid fuel concentrations to minimize the energy of a potential deflagration in the tank vapor space, thus limiting the amount of waste that could be released to the environment; limits on the curie content and flammable fuel concentrations in the tanks to reduce the source terms available for release; limitations on the tank inventory to ensure that evaporation is the mechanism for release (versus entrainment at higher tank levels), and emergency response actions to mitigate the doses to onsite and facility workers.

The functional classification (safety class or safety significant) of these or other controls identified during resolution of the chemistry issues or update of the safety analysis have not been finalized. This classification will follow the safety philosophy of prevention first, mitigation second, recovery last, where the primary barrier becomes the first line of defense and subsequent lines of defense are added to protect the barrier from unacceptable events. Barriers will also be added as a means of protecting assumptions such as fuel or oxygen concentrations, source terms, and response to accidents. These barriers will be classified based on their importance relative to the preventive barriers. It is anticipated that some of the preventive and mitigative barriers will not be classified as safety class or safety significant, but will be controlled and maintained as part of the defense-in-depth philosophy. This meets DOE Order 5480.23 and 29 CFR 1910.119.

The following constraints will be used in defining the safety strategy:

- Safety Systems (structures, systems and components that are relied upon to perform a passive or active function) and necessary attendant administrative controls will be identified in order to ensure safety of the public and worker and protection of the environment.

- Prevention and mitigation measures will consider all modes of operation, under both normal and accident conditions, as defined in the facility's authorization basis. The facility's authorization basis will be revised to reflect measures relied upon to perform prevention and mitigation functions.

- To the extent practical, multiple lines of defense will be credited for prevention/mitigation of each credible event, as governed by applicable WSRC criteria in Manual E-7, procedure 2.25.

## 3.1 Overall Safety Strategy

Previous attempts to define a fuel control safety strategy for the ITP Facility were based upon an incomplete understanding of mechanisms and rates governing the generation, retention and release of benzene. As discussed in previous sections, the ITP facility is transitioning from a strategy of fuel control to a strategy of oxygen control. However, because large releases of benzene could result in challenging the systems put in place to prevent deflagration, defense-in-depth will be provided through a combination of administrative controls, technical safety requirement (TSR) limits, and additional engineered systems which limit the generation, retention and release of benzene.

Safe operation of the waste tanks under all conditions and during all evolutions involves control of those parameters which could result in internal tank deflagrations or major releases of material (leaks, spills, overflows). This report deals specifically with that portion of tank operation which is related to deflagration controls. It is commonly understood that the majority of risk to facility workers and onsite personnel is during the period of normal operation, although the consequences to these populations, as well as the offsite public, may be worse during abnormal event and accident conditions. The tank operating conditions which will prevent adverse consequences to all populations during all possible operational and accident conditions have been defined, the details of which are discussed in this and the following section.

A multi-disciplined team was convened to evaluate the method of operating the waste tanks which would provide protection of all populations under all potential plant conditions and accidents. Four potential methods of operation were evaluated. These included:

1) Negative pressure CLFL control only
2) Negative pressure, composite limiting oxygen concentration (CLOC) control with fuel control as defense-in-depth
3) Positive pressure CLOC control with fuel control as defense-in-depth
4) Positive pressure oxygen control only

Each of these methods of operation was reviewed for impact on routine operations, maintenance, contamination control, operability of interfacing facilities, inherent safety, recovery from upset conditions, cost, schedule, procedures, and training (Ref. 6).

The inability to completely seal the tank from external leakage during positive pressure operation was of major concern to the Operations and RadCon personnel based on extensive tank farm experience. Regardless of the amount of effort spent sealing the tank penetrations, it is impossible to completely seal the slurry pump ROTEK seals and certain other penetrations, and tank top contamination (with subsequent contaminated area classification) will occur. Working in huts on the tank top introduces hazards of benzene exposure, contamination of personnel, and nitrogen asphyxiation, and would require engineered features to ventilate the hut (negative tank pressure is now used) and use of self contained breathing apparatus. All enclosed spaces (such as valve boxes, valve houses, maintenance huts, etc.) would have the potential for significant contamination, benzene, or nitrogen concentrations. This would introduce extensive problems for operator rounds and routine equipment operation, and would require either personnel protective equipment (personal monitoring, respirators, plastic suits, etc.) or permanent tank top monitoring to protect personnel. Interaction with other facility segments such as the filter stripper building, laboratory, and diversion boxes would require significant engineered or operational controls. Contaminated and hazardous vapors could enter the laboratory through drain lines, enter the filter/stripper processes during jumper removal, or enter the cold feeds area through chemical addition lines. Significant engineering effort and redesign of existing facilities would be required to address all of the facility worker issues encountered through routine operation at positive tank pressure.

Due to the many concerns about contamination of the tank top, releases of benzene to unprotected areas, nitrogen buildup in enclosed spaces, and interaction with interfacing facility segments, the consensus of the team was to avoid positive pressure operation in all but the most extreme conditions (extended ventilation outage, high tank bulk oxygen concentration, NPH event, etc.). Also, during normal operation, provided the tank vapor space is shown to be well mixed with respect to oxygen (assumption 9), the benefits of operating at positive pressure to prevent inleakage are offset by the hazards introduced for the facility worker. With this as a basis, the philosophy of negative pressure oxygen control as the normal operations mode was adopted. Since upset and accident conditions could adversely affect the oxygen concentration in Tanks 48 and 49, a standby mode of positive pressure oxygen control was also adopted. In addition, since tank breaches are necessary for removal of specific equipment or performance of certain operational evolutions, two separate maintenance modes are required. The first mode involves small breaches of containment for short durations (duration being defined). The second mode would be major tank breaches of greater duration (possibly days). Each of these modes of operation, the hazards associated with each, recovery or transitioning between modes, and the safety strategy during these modes, are discussed in the next section.

By implementing a prevention/mitigation approach for tank deflagrations, WSRC has determined that, although the required safety systems may not be upgraded to fully meet safety class or safety significant requirements (subject to a backfit evaluation), multiple layers of safety will exist to minimize the potential of any event causing a dose which exceeds evaluation guidelines.

The recommended upgrades consist of modifications necessary to make the systems meet NPH qualifications, significantly increase the reliability of the systems, and enable the systems to function following a DBA. A single failure review will be performed on existing systems and interlocks designated as safety class. This review will be accomplished according to the WSRC backfit methodology (Ref. 8). Identified single failures will either be corrected or compensatory measures will be specified to make it acceptable to operate with the single failure vulnerability. The identified single failure issues will be discussed and justified in the FSAR. All new systems (e.g., safety class nitrogen) will be designed to comply with single failure criteria with the exception of those designs which use parts of, or interface with, existing systems. For these cases, some passive single failures could exist. These points will be qualified and the single failures justified in the FSAR.

## 3.2 Modes of Operation

As discussed in the previous section, four separate modes of operation are being proposed for Tanks 48 and 49. Each of these modes is discussed in greater detail below.

Since the benzene generation, retention, and release rates for Tank 50 are sufficiently low (i.e., release rates will be diffusion limited), this tank will be operated in the same manner as the other air-based High Level Waste tanks (assumptions 1, 2, 3, 16, 17,18). Additional controls will be placed on Tank 50 operation to assure facility safety under this mode of operation. These controls will be addressed for each separate mode of operation discussed below.

Operations Mode

The normal operations mode for Tanks 48 and 49 will be negative pressure oxygen control with fuel control as defense-in-depth. Under this mode of operation these tanks will be maintained under a slight vacuum (as close to atmospheric pressure as the equipment will permit) to assure contamination control and containment of benzene and nitrogen vapors. By operating the tanks as close to atmospheric pressure as possible, oxygen inleakage will be minimized (assumptions 10,11). A program to locate and seal leak sources and engineered features to introduce nitrogen directly into major leak sites will assure that oxygen inleakage is minimized and localized concentrations are diluted and quickly mixed by the localized addition of nitrogen. A high flowrate through the tank vapor space will assure adequate vapor space mixing of both oxygen and flammable vapors (assumption 9).

The vapor space oxygen concentration of Tanks 48 and 49 will be monitored and the tank will be taken to positive pressure (standby mode) through a set of interlocks upon oxygen concentration reaching a setpoint limit. In addition, the normal nitrogen system flowrate will be isolated, the tank ventilation system will be isolated, and the tank taken to positive pressure (standby mode) upon detection of low normal nitrogen flow to that tank. Automatically placing a tank into standby mode will stop inleakage prior to the vapor space exceeding the composite limiting oxygen concentration (CLOC) for benzene/hydrogen mixtures (assumption 14) (Ref. 2). The CLOC must be used since sufficient hydrogen is generated due to radiolytic decay such that its release into the tank vapor space, when the flammable fuel concentration is above the CLFL value, could reduce the minimum oxygen required to produce a flammable vapor for a typical benzene-only system. This CLOC has been determined to be 9% at a maximum hydrogen to benzene ratio of 60% (assumption 8) (Ref. 2). The CLOC value will be established as a limiting condition of operation (LCO). Administrative TSR controls will be implemented to assure the hydrogen concentration is minimized at all times so as not to adversely impact the CLOC assumption (assumptions 7, 8).

The normal nitrogen supply system will be supplemented by a cryogenic nitrogen plant. The line from the cryogenic plant will have an oxygen monitor and associated high oxygen interlock installed on the incoming line to isolate it from the normal nitrogen supply if a malfunction occurs. A sufficient flowrate of normal nitrogen will be supplied to Tanks 48 and 49 to ensure the vapor space is maintained below the CLOC for design basis inleakage rates and to ensure adequate mixing of the tank vapor space (assumptions 7, 8, 9, 10, 11, 12). This minimum flowrate will be established as an LCO limit. A redundant supply of backup nitrogen will also be provided to assure positive tank pressure can be maintained for a minimum of 4 days when in standby mode. The backup inventory will be established as an LCO condition (assumption 11).

The oxygen monitoring/interlock system for Tanks 48 and 49 and safety class nitrogen systems will be qualified to all applicable natural phenomena hazard (NPH) events, or alternate means of performing these functions will be provided (e.g., seismic switches or operator actions on tornado watch). Tank penetrations will be NPH qualified, as necessary, to protect the design basis oxygen inleakage and backup nitrogen flowrate and inventory (assumption 11). A TSR control will be established to periodically verify the tank integrity.

A second level of control will be provided to continuously monitor each tank's vapor space flammable fuel concentration and maintain it below 25% (indicated) of the CLFL (assumption 2, 3, 6). This monitor will be interlocked to the appropriate tank transfer, slurry and filter feed pumps, to reduce benzene release rates (assumption 3). The bulk vapor space fuel concentration will be established as an LCO condition (assumption 12).

Pending verification through revised safety analyses, the unmitigated consequences of deflagrations in Tanks 48, 49, and 50, at bounding limits on tank inventory, curie content, fuel/oxygen concentrations, etc., are anticipated to be below safety class evaluation guidelines (assumption 5). Even so, the unmitigated consequences of vapor space deflagrations will be significantly reduced through implementation of mitigative measures (assumptions 2, 3, 4, 6, 7, 8, 15). The first measure is a limitation on the source term available for release. An administrative control on the maximum curie concentration of the feed material to Tank 48, by sampling prior to transfer to Tank 48, will ensure that the unmitigated consequences due to deflagrations are below the safety class evaluation guidelines (assumption 15).

A further LCO limit on liquid level in Tanks 48 and 49 (~ 800,000 gallons) will reduce the consequences significantly (assumptions 4, 15). This is achieved by limiting the release mechanism to evaporation instead of entrainment, which significantly reduces the volume of material released to the atmosphere. During normal operations, the tank vapor space will be maintained less than 25% (indicated) of the CLFL by implementing administrative TSR controls on excess TPB concentration and LCO controls on tank temperature (assumptions 1, 6, 16). The liquid benzene and hydrogen concentrations will be maintained low through an administrative TSR control on periodic slurry pump operation (assumption 2). Other chemical additions (oxalic acid, washwater, etc.) will be established as administrative TSR controls to minimize vapor space benzene concentrations. Controlling the amount of flammable material provides further mitigation by reducing the energy of the deflagration and thus the amount of material which can be released (assumption 15).

Under this mode of operation, the most difficult concern to address is one of localized oxygen and/or benzene pockets, which could result in small pockets of flammable mixtures under certain conditions. To address this concern the facility will reduce the inleakage rate and the size of leaks by further sealing of the tank, will operate the tank less negative, will inject nitrogen directly at the source(s) of major leakage to mix the incoming flow and dilute it at the source(s), and will control fuel generation through monitoring and interlock actions and through administrative programs to reduce the source material and keep the liquid concentrations low (assumptions 1, 2, 3, 4, 6, 7, 9, 10, 12, 15). By combining a safety class level of oxygen control with a safety significant level of control on fuel concentration in the liquid and vapor spaces, the concern of adequate mixing of the vapor space is reduced to an acceptable level of risk. In addition, plant test data is being analyzed to show that significant flowrates through the vapor space and the swirl induced by the nitrogen injection nozzles provide adequate mixing under all but the most severe releases of benzene (assumption 9). These types of major releases will be prevented through the administrative controls on liquid concentration (assumption 2).

A number of engineered features and administrative controls will be implemented to protect the operations personnel from process hazards under this mode of operation. These include interlocks to isolate normal nitrogen during low exhaust flow conditions (prevents significant releases to the tank top due to high tank pressure), alarms and emergency response actions to evacuate personnel from the tank top and other interfacing facility segments on high tank pressure, and interlocks to stop slurry, transfer, and filter feed pumps to reduce the benzene release rate on loss of ventilation flow (assumption 19).

For Tank 50, which will contain only wash water and a small quantity of filtrate from the Late Wash Facility, the benzene generation rate has been determined to be sufficiently low to eliminate the need for inerting as the primary safety strategy (assumptions 1, 2, 3, 6, 9, 12, 16, 17, 18) (Ref. 3). Due to the low curie activity of the material in this tank, the consequences of deflagrations will be significantly lower than the safety significant evaluation guidelines, even under bounding tank parameters (inventory, fuel concentrations, etc.) (assumption 15) (Ref. 2). Additional TSR controls will be placed on the tank operation to further mitigate the consequences of deflagrations. These will include LCO limits on the tank temperature and TPB concentrations (to limit benzene generation to several orders of magnitude below the CLFL value), and LCO limits on the inventory (approximately 600,000 gallons) to eliminate releases due to entrainment from vapor space deflagration (assumptions 1, 15, 16, 17, 18). Ventilation flowrates will be established and controlled through interlock actions and TSR controls to ensure vapor space flammable fuel concentrations are minimal and to provide at least 9 days to CLFL (assumption 6) following loss of ventilation (assumption 3). In extreme cases where ventilation flow is lost and tank parameters are at their bounding values, portable ventilation can be installed to provide emergency ventilation. Adequate mixing of the vapor space is not an issue for this tank as the benzene release rates will be significantly below the release rate where, upon loss of ventilation, molecular diffusion in the vapor space can provide sufficient mixing to meet the 9 days to CLFL requirement (assumption 3).

The systems which will be credited under this mode of operation for all three tanks, their preliminary functional classification, and the safety functions they will perform are listed in Table 2.

Standby Mode

During abnormal or accident conditions, Tanks 48 and 49 will be automatically transitioned from negative pressure oxygen control to positive pressure oxygen control. This will stop oxygen inleakage before the vapor space oxygen concentration can exceed the CLOC limit (assumption 14). Given the LCO controls established under the operations mode, the fuel concentration will initially be less than 25% (indicated) of the CLFL, which will further prevent combustible mixtures from forming (assumption 6). However, fuel control will not be credited under this mode due to the uncertainty of tank parameters (temperature, liquid level, etc.) and the length of time which the facility may be under this mode. Since the ability to deplete benzene from the liquid or purge it from the vapor cannot be assured, the vapor space may reach the CLFL. Oxygen control is the only certain way of preventing explosive mixtures from forming under these conditions. The oxygen concentration in the tank can be monitored when in this mode of operation for all but post NPH conditions. The abnormal and accident conditions which require standby mode are: prolonged loss of ventilation, loss of primary nitrogen, high oxygen concentration in the tank vapor space, loss of power, and NPH events (tornado, high wind, seismic).

By maintaining the tank vapor space below the CLOC and minimizing additional oxygen inleakage, the concerns of localized flammable fuel concentrations in the tank and adequate tank vapor space mixing are eliminated. However, positive pressure operations present an additional hazard to operations personnel. By minimizing the nitrogen flowrate into the tank during this mode of operation, and by interlocking off the transfer, slurry, and filter feed pumps to reduce the benzene release rate, the amount of contamination, benzene, and nitrogen exiting on the tank top will be reduced (assumption 19). Emergency response actions on loss of ventilation, high tank pressure, severe weather, and seismic events to evacuate personnel from the tank top and from all interfacing facility segments will further prevent exposure to the facility worker.

Transitioning from standby mode of operation to normal operation for Tanks 48 and 49 is difficult to specify due to the many possible reasons why the tanks may have been placed in this mode. This transition is the most critical period of tank operation, as it must be controlled to limit the amount of oxygen inleakage and assure an adequately mixed vapor space when negative pressure is reestablished (assumptions 9, 12). The first condition which must be established prior to starting the transition will be to assure the tank vapor space is below the CLFL. This may require the facility to remain in standby mode for a period of time until the nitrogen purge can dilute/remove the benzene/hydrogen vapors, or increase the nitrogen flowrate to expedite this action. Once the vapor concentration reaches 25% (indicated) of the CLFL value, restoration of normal ventilation/purge flow can begin.

Since the ventilation flowrate must be established without drawing significant quantities of oxygen into the vapor space or causing localized pockets of high oxygen concentration at a time when the vapor space may contain localized flammable fuel concentrations, a purge rate sufficient to assure adequate mixing (TSR value) must first be established (assumption 9). At this point, the flowrate between nitrogen and exhaust may be balanced to provide negative pressure in the tanks. This means of transitioning will ensure that a flammable mixture does not form by both reducing the flammable fuel concentration in the vapor space and minimizing/mixing the oxygen inleakage. The tank vapor space must be monitored for oxygen concentration and taken back to positive pressure if the CLOC is approached (assumption 12). This action is required regardless of the fuel concentration in the vapor space. Furthermore, major sources of tank agitation (slurry, transfer, filter feed pumps) will not be operated (condition for this mode of operation) which will eliminate the major mechanism for benzene release (assumption 19).

The systems which will be credited under this mode of operation for Tanks 48 and 49, their preliminary functional classification, and the safety functions they will perform are listed in Table 2.

Standby mode of operation for Tank 50 is not applicable since this tank will always be in air-based operation with greater than 9 days to reach CLFL.

Minor Maintenance Mode

There will be times during Tank 48 and 49 operations when the pressure boundary must be breached to perform routine or non-routine operations or maintenance. An effort is underway to redesign certain aspects of the tanks to reduce the number of routine breaches required. This effort includes developing methods of sampling, level verification, and slurry pump startup which do not require opening tank penetrations. Under this mode of operation, oxygen concentrations at the point of the tank breach could exceed the CLOC value. To permit this condition to exist for the short duration of this activity, additional administrative controls on fuel concentration in the vapor space and increased LCO surveillances of both fuel and oxygen are warranted.

As a condition for entering this mode of operation, the tank liquid benzene inventory must be verified to be sufficiently low by running the slurry pumps just prior to entering the mode or assuring that the activity is performed within the benzene depletion pump run frequency (will be an administrative TSR control), and by verifying that the liquid benzene concentration is extremely low (actual value being determined) (assumption 2).

Entry into this mode will only be permitted for short durations (duration being defined) and for very specific activities (small tank breaches). Since the tanks are still considered under oxygen control, the oxygen monitoring and interlocks will be required to be operable and the tank oxygen concentration verified more frequently to ensure it is not increasing significantly. In addition, the CLFL monitoring system and interlocks must also be operable and the tank CLFL concentration verified more frequently to enable quick response to reestablish the pressure boundary should fuel concentration begin to increase. All sources of agitation (slurry, filter feed, and transfer pumps, routine liquid additions, etc.) will be controlled as a condition of entering this mode to prevent benzene releases (assumption 19).

This mode is not applicable to Tank 50, as it will be in air-based mode at all times. Breach of the pressure boundary could result in spurious pressure excursions (loss of negative pressure) and subsequent operations response (evacuate the tank top), but would not have a safety class or safety significant function associated with it.

With these engineered features and administrative controls in place, the risk of operation under this mode is minimized and considered acceptable.

Major Maintenance Mode

Although very infrequent, there is a need to breach the Tank 48 or 49 pressure boundary for extended periods of time to remove equipment associated with large tank penetrations (e.g., pumps, isolation dampers, monitoring equipment, etc.). During these evolutions it will be impossible to maintain oxygen concentration in the tank vapor space less than the CLOC, under negative tank pressure. The negative pressure is necessary to prevent gross contamination of the tank top and releases of benzene and nitrogen which are hazardous to the facility worker. The tank must be transitioned to air-based operation and fuel control established as the primary safety strategy. Therefore, entry into this mode of operation will require sufficient understanding of the tank liquid conditions and control of other parameters affecting benzene generation and release (assumptions 1, 2, 3, 4, 9, 12). During this mode, the normal and safety class nitrogen systems will be maintained operable to facilitate re-establishment of oxygen control.

Setting up the tank conditions for entering this mode of operation must be performed under operations mode, since that is the only mode which will permit depletion of the liquid benzene while still maintaining both oxygen and fuel control (assumptions 2, 3, 6, 7, 8, 9, 10, 12). Prior to entering this mode, when practical, the tank inventory will be reduced to a low level to provide a large vapor space and small source term (both radioactive and benzene). Verification of low liquid benzene inventory (either through liquid sampling or monitoring of tank vapor space during slurry pump operation), adequate understanding of the retention capability of the liquid, administrative control of tank initial temperature, isolation of all means of agitation, and monitoring of ventilation system operability will all ensure that the vapor space cannot reach flammable limits during the duration of tank breach (assumptions 1, 2, 3, 6, 9, 12, 19, 20).

The time that the tank is permitted to be in this mode of operation will be controlled by an LCO to assure a flammable concentration cannot be reached on loss of ventilation and to ensure adequate time is available to reestablish oxygen control. This time will be based on the generation rate at the entry temperature (an LCO control) (assumption 1), an assumption that all of the benzene is retained in the liquid up to the point of release, and that all the benzene is released as vapor during unexpected tank agitation (seismic event, inadvertent transfer, etc.). This is conservative since the vapor space and liquid fuel concentrations will initially be very low (prerequisite to entering the mode) and seismic/liquid addition releases are anticipated to be much less than those resulting from operation of the slurry pumps (assumptions 2, 20).

Administrative controls will be established to ensure timely recovery actions from loss of ventilation, increasing benzene in the vapor space, or increasing liquid temperature, which may include re-establishment of oxygen control or use of portable ventilation under certain conditions. In addition, both Tanks 48 and 49 will not be permitted in this mode concurrently. The facility will initiate actions to transition back to standby or operations modes upon a tornado warning to preclude this accident initiator.

Transitioning from this mode of operation will involve reestablishment of the pressure boundary, reinitiation of the normal nitrogen supply flowrate, monitoring of the oxygen concentration until below the oxygen interlock value, and then placing the interlock in operable status. At this point the tank can be declared back in operations mode. Until the oxygen concentration is returned to below the CLOC value, the proper response to loss of ventilation will be to install portable ventilation and reestablish airflow through the tanks. Subsequent actions will include reestablishment of the normal nitrogen flowrate with the ultimate goal of reestablishing inerting.

This mode is not applicable to Tank 50 as the tank is normally in air-based mode of operation. Major tank breaches may impact pressure control (loss of negative pressure), but this will be anticipated and controlled as part of the job requirements under the radiation control program.

The systems which will be credited under this mode of operation for Tanks 48 and 49, their preliminary functional classification, and the safety functions they will perform are listed in Table 2.

3.3 Prevention / Mitigation Controls

The Prevention/Mitigation approach for radiological and chemical releases due to deflagrations is based on the simple concept that they should be prevented, and, if they can't be prevented, their consequences should be mitigated. For Tanks 48 and 49, in-vessel deflagrations are prevented by ensuring the tank inerting systems and select interlocks are operational during normal, abnormal, and accident conditions; or by ensuring sufficient flowrate through the tank vapor space and that the tank conditions support controlling the fuel below the CLFL. The vapor space of these tanks is maintained below the CLOC or the CLFL under TSR controls. In addition, although not a safety class or safety significant function, spark sources are controlled to the maximum extent possible, including the installation of lightning dissipation systems in the ITP facility (assumption 13).

CLOC control is achieved by providing sufficient inerting gas when the tanks are under slight vacuum (operations and minor maintenance) or by pressurizing the tanks with inerting gas to prevent oxygen in-leakage (standby). For Tank 50, the flowrate through the tank must be sufficient during normal operation to maintain the vapor space below 25% (indicated) of the CLFL. This requirement also applies to Tanks 48 and 49 when under all but standby mode.

Although it is anticipated that the consequences of potential deflagrations will be below the safety class evaluation guidelines, they will be further mitigated by limiting the tank level to less than that value where the releases due to vapor space deflagrations are governed by entrainment of aerosolized material (assumption 5), and by limiting the amount of fuel and oxygen in the vapor space to reduce the explosive energy and subsequent amount of released material should explosive mixtures form (assumption 15). The consequences of postulated design basis accidents with the inerting system and level control credited will be well below the safety class evaluation guidelines. Even though the consequences of tank deflagration may be below the evaluation guidelines at maximum tank level, the backup inerting systems and tank level measurement (already classified as safety class for above ground spill control) will be classified as safety class to provide additional safety margin. The tank levels will be controlled as an LCO.

Monitoring of CLFL concentration in the vapor space and interlocks which stop transfer, slurry, and filter feed pumps and transfers will be classified as safety significant to limit the amount of benzene which can be released into the tank vapor space and provide defense-in-depth for the inerting systems (assumptions 12, 19). In addition, although not required nor classified as safety class or safety significant during operations, standby, or minor maintenance modes, tank ventilation will provide additional prevention of tank deflagrations by controlling the fuel source during normal operation (assumption 6).

Tank ventilation flowrate is a requirement during all modes of operation for Tank 50 and during major maintenance mode for Tanks 48 and 49. The verification of this flowrate will be an LCO requirement. However, the actual safety class or safety significant functions will be maintaining 9 days to CLFL upon loss of ventilation, use of portable ventilation upon loss of installed ventilation systems, and monitoring of tank vapor space for CLFL (assumption 6). Therefore, the normal exhaust flowrate instrumentation and TSR surveillance, the temporary ventilation equipment, and the CLFL monitors are the only safety equipment during these modes of operation.

The inner waste tank structure is the primary barrier to prevent release of hazardous material, which would be a safety class function for Tanks 48 and 49 and safety significant for Tank 50 if this material is released to the surface water supply. Since the releases would be below ground for all but deflagration or surface release events, maintaining this barrier is classified as a safety significant function. However, for conservatism, the inner tank confinement boundary is classified as safety class for Tanks 48 & 49 and safety significant for Tank 50. The purge/ventilation systems and select interlocks (oxygen and CLFL) are designed to maintain the tank confinement by preventing internal deflagrations. If an in-vessel deflagration were to occur in the waste tanks, the tanks would contain most of the material, but radioactive releases to the environment could result from over-pressurization of the inner tank (Ref. 13, 14). The ability of the inner tank to withstand minor internal deflagrations is not a safety requirement, but provides an additional mitigative feature (assumption 5) (Ref. 13, 14). The secondary barrier to preclude liquid releases due to inner tank deflagrations, is the outer tank annulus. The annulus has been designated as safety significant.

## 3.4 Functional Performance Requirements

Since the facility is in a backfit situation, the upgraded systems may still include single failures. This approach is in alignment with backfitting efforts at other SRS facilities (DWPF, RTF, etc.). All departures from safety class requirements, including single failure vulnerabilities, if any, will be documented and justified in the Final Safety Analysis Report (FSAR).

Interlocks

The DCS is not currently relied upon to automatically complete any function that is required to prevent or mitigate an accident. However, efforts are ongoing to upgrade and qualify the DCS as safety significant. This would enable its use for remote monitoring of safety parameters and for software controlled safety significant interlock functions. Interfaces with the DCS will be electrically isolated from safety class functions to the maximum extent possible. All interfaces which cannot be isolated, if any, will be documented and justified in the FSAR. Local instruments or hardwired interlocks will be used to perform all safety class monitoring and/or interlock functions.

For Tanks 48 and 49, there are two primary interlock systems required for prevention of tank deflagrations: oxygen control (safety class) and fuel control (safety significant). The oxygen control interlock will activate upon a high oxygen concentration as measured through a set of multiple height, multiple sector sample arrays, and will isolate the exhaust system and normal nitrogen system and initiate the safety class backup nitrogen system when oxygen levels approach the CLOC for a benzene/hydrogen mixture (assumption 12). This interlock action will pressurize the tanks and preclude additional oxygen inleakage, thus preventing a flammable mixture from forming (assumption 14). This interlock applies only to Tanks 48 and 49 since Tank 50 will always be in air-based operation.

The fuel control interlock will monitor the fuel concentration of the bulk vapor space and will stop all controllable means of agitating the liquid (transfer pumps, slurry pumps, filter feed pumps) when the vapor space reaches 25% (indicated) of the CLFL for a benzene/hydrogen mixture (assumptions 12, 19). By stopping these means of agitation, the benzene release rate will decrease to minimal levels and the ventilation flowrate will dilute the vapor concentration to low levels (assumptions 6, 9, 19). This same action can be credited with decreasing the benzene release rate during loss of ventilation scenarios to protect the time to CLFL limits and associated response actions (assumptions 2, 3, 6, 19, 20). This interlock is applicable to Tanks 48, 49 and 50. The benzene concentration will also be monitored by separate benzene monitors on Tanks 48, 49, and 50 through sampling arrays, but interlock action will not occur using these instruments. The benzene monitors on Tanks 48 and 49 will, however, be used to assure entry conditions into the minor and major maintenance modes, and as a surveillance function when in major maintenance mode.

A safety significant interlock is required for Tanks 48 and 49 to protect facility workers upon loss of ventilation (exhaust flow). Loss of ventilation, as indicated by either low ventilation flowrate or high tank pressure, will result in isolation of the purge exhaust path and normal nitrogen supply and subsequent initiation of backup nitrogen. Although the tank will achieve a positive pressure after a time delay, isolation of the normal nitrogen supply will prevent rapid pressurization of the tanks and limit the radioactive material, benzene, and nitrogen releases to the tank top, interfacing facility segments, and other confined spaces.

Purge / Ventilation System Requirements

Purge/inerting systems, either through CLOC or CLFL control, prevent deflagrations in the waste tanks. The safety grade purge system must be able to supply sufficient purge flow to the applicable waste tanks for 4 days following design basis events, and must not rely on electrical power. The 4 day requirement is based on engineering judgment as being a reasonable period of time for which to design critical supply capacity, such as nitrogen, and within which recovery operations can reasonably be accomplished. This timeframe is consistent with the design of similar systems in DWPF (Ref. 4). Resupply of nitrogen is accomplished through vendor contract. A nominal 1 hour time frame has been preliminarily established for initiating the safety class nitrogen supply based on a 12 hour time before exceeding CLOC upon complete loss of purge/ventilation with subsequent oxygen inleakage (due to atmospheric transport mechanisms and diffusion) (Ref. 5).

During air-based operation (major maintenance for Tanks 48 and 49 and all modes for Tank 50), the 9 days to CLFL requirement is the critical safety control. However, to assure that this control will not be challenged, flowrate through the tank is also a critical parameter (assumptions 2, 3, 6, 9, 12). This flowrate must be sufficient to keep the bulk vapor flammable fuel concentration below 25% (indicated) of the CLFL value based on the worst case design basis release rate (assumptions 2, 3, 6, 9, 12). Monitoring of flowrate to detect loss of ventilation is a safety function, as the time to CLFL upon loss of ventilation flow will be sufficiently long to enable installation of alternate ventilation equipment for these tanks. This timeframe has been established as greater than 9 days to reach CLFL, and is protected by TSR administrative controls (assumptions 1, 2, 3, 6, 19, 20). For this reason, the normal ventilation equipment and its support equipment (fans, controls, power supplies, etc.) will not be classified as safety significant. The flow monitoring instrumentation will, however, be classified as safety class or safety significant for all modes in Tanks 48, 49, and 50. The portable ventilation equipment will be classified as safety class for Tanks 48 and 49 and safety significant for Tank 50 during air-based mode of operation.

Since the flowrates for maintaining the vapor space less than 25% (indicated) of the CLFL are based on the benzene release rates, which, in turn, are dependent on the generation and retention values, confirmation of adequate design and established operational limits is dependent on the outcome of the chemistry program (assumptions 1, 2, 3). Bounding values based on previous experimentation and actual plant operation will be used to validate existing design and set preliminary operational values. These will be confirmed as part of the ongoing chemistry effort and prior to approval of the safety documentation.

CLFL monitors will be used during these modes to assure the vapor concentration is less than 25% (indicated) of the CLFL. These monitors will be classified as safety significant.

Waste Tank Requirements

As stated earlier, the inner tanks for waste Tanks 48 and 49 are classified as safety class for prevention of material releases, even though the actual classification would be safety significant since the releases would be sub-surface. In addition, the tank annulus has been designated as safety significant for defense-in-depth. Both the inner tank and annulus for Tank 50 will be classified as safety significant due to the significantly lower source term in this tank (Ref. 3).

The inner tanks for waste Tanks 48 and 49 also serve as the primary pressure boundary for containment of radioactive material and fuel sources, and for prevention of oxygen inleakage. This boundary must be maintained within its analyzed conditions (inleakage, NPH qualification, etc.) both to protect the nitrogen flowrate and supply capacity under all conditions, and to prevent excess radioactive material, benzene, and nitrogen releases when in standby mode. Administrative controls on breach of this boundary, as well as periodic leak rate verification requirements, will be imposed (assumptions 10, 11).

The inner tank for waste Tanks 48, 49, and 50 also perform the function of directing purge flows through the vessel and out the stack to dilute and remove any flammable vapors, and to contain this material under loss of ventilation conditions.

Although the inner tanks are not credited with performing a safety function to withstand internal deflagrations, analysis has shown that they will withstand small deflagrations, as could be the case for localized fuel concentrations or very short duration transient events (either oxygen inleakage or fuel generation/stratification) (Ref. 13, 14).

Pump Operations

Periodic operation of the slurry pumps in Tanks 48 and 50, and eventually in Tank 49, is necessary to preclude flammable material buildup in the tank liquid. Retention of benzene and hydrogen is a concern since the vapor space concentration (and subsequent flowrate for dilution) is based on the conservative assumption of instantaneous release of any trapped material. Periodic operation of the pumps will release any trapped benzene or hydrogen in a manner that will be controlled through vapor space interlock action (never to exceed 25% (indicated) of the CLFL) and will be within the minimum system flowrate (assumptions 2, 9, 12, 19). By maintaining the liquid inventory low, a substantial time to CLFL upon loss of ventilation can be ensured, which is a safety class requirement for Tanks 48 and 49 for entering minor maintenance mode (oxygen + fuel control) or major maintenance mode (air-based operation), and a safety significant requirement for Tank 50 (assumptions 1, 2, 3, 6, 7, 8, 16, 17, 18). It is also necessary to support defense-in-depth controls on vapor space fuel concentrations during operation and standby modes in Tanks 48 and 49.

The safety class functions for slurry pump operation to deplete benzene is to assure that the minimum required number of pumps are operational to support benzene depletion (assumption 2). For this safety class function for Tanks 48 and 49, it is not necessary to have pump support equipment operational, nor to have any portion of the pumps which can be serviced without breaching the tank pressure boundary operational, since the pumps are only required to deplete benzene prior to entering major maintenance mode. The minimum number of pumps will be based on adequate mixing of the maximum allowable liquid volume (assumptions 2,7). This number of pumps, along with the criteria for determining operability, will be defined in TSR controls.

The pump run frequency is highly dependent on verification of benzene generation, retention, and release information being obtained under the chemistry program (assumptions 1, 2, 3, 7). Bounding values obtained from previous experimentation and actual plant operations are being used to set preliminary values, but sufficient understanding in these areas must be gained from the ongoing chemistry efforts to support approval of the TSR frequencies.

Another safety class function for Tanks 48 and 49 is to periodically deplete the liquid of hydrogen to protect the CLOC. Although analyses are ongoing, it is anticipated that the time between these pump runs will be sufficiently long so as to support not requiring continuous operability nor classification of the support systems as safety class. Again, the minimum number of pumps will be maintained operable to assure this depletion can be achieved within the specified timeframe (assumptions 2, 7).

Vapor Space Monitoring

Monitoring of the vapor space in Tanks 48 and 49 for oxygen and fuel concentrations is essential for preventing tank deflagrations. During operations, and minor maintenance modes, Tanks 48 and 49 will have a safety class oxygen monitoring function and a safety significant fuel monitoring function. During major maintenance mode for Tanks 48 and 49 and all modes for Tank 50, the fuel monitoring function will be safety significant. Oxygen monitoring in Tank 50 is not required since the tank is always in air-based mode of operation. During standby mode for Tanks 48 and 49, since the flowrate through the tanks may not support adequate vapor space monitoring, neither of these is a required safety function. Instead, the nitrogen purge flowrate will be used to assure safe operation under standby mode, given that the tank pressure boundary integrity is maintained (will be controlled through surveillance and will be NPH qualified) (assumption 11). However, for all but post-NPH events, the oxygen concentration will be monitored when under standby mode to assure a concentration gradient does not exist.

Oxygen monitoring will be performed through a set of multiple height, multiple sector sample arrays in the tank vapor space. Monitoring of fuel concentration and associated interlock functions will be for the bulk vapor space only, which will assure that bulk fuel concentrations above 25% of the CLFL will not exist under most tank scenarios (assumptions 9, 12). The assumption of an adequately mixed vapor space for the fuel monitoring function during normal ventilation flowrates (operations, minor and major maintenance modes) is being validated using data obtained from plant testing (Ref. 6).

In addition, to assure that the tanks can be maintained in a safe condition following upset or accident events (minimizing oxygen inleakage), a pressure indicator will be installed (or credited if already existing) to permit adjustment of the safety class nitrogen flowrate into the tanks which will assure positive pressure (Ref. 5). This indicator will not be NPH qualified, but a spare indicator will be maintained in a seismically qualified structure.

Although increasing the safety class nitrogen flowrate may impact the 4-day nitrogen supply, excess inleakage is considered a beyond-design-basis condition (tank inleakage is qualified) and is a prudent action to take to prevent an immediate unsafe condition from developing.

Tank Level Detection

Tank level monitoring is required to both prevent overflows and subsequent liquid path releases (safety class function) and mitigate the consequences of internal tank deflagrations (safety significant function). The mitigative function is achieved by keeping the level below that value where deflagrations result in entrainment of liquid, which limits the release mechanism to evaporation (assumption 15). This mitigative measure will result in an order of magnitude reduction in the consequences from deflagrations. The level indicator will be safety class for prevention of tank overflows, but safety significant for mitigation. Level control will be established as a TSR control for Tanks 48, 49, and 50.

Tank Temperature Monitoring

A major parameter in the control of benzene generation, and subsequently in its release rate, is the temperature of the tank liquid (assumption 1). Benzene generation due to STPB breakdown is significantly reduced by keeping the tank temperature low (e.g., <40°C). To protect the pump run frequency and the time to CLFL values specified in this safety strategy, the tank liquid temperature must be maintained below the design basis value (actual value being determined as part of the chemistry program) (assumptions 1, 2). Tank liquid temperature can be affected by one of three plant conditions: radioactive decay heat, temperature of incoming liquid streams, and pump energy input. Administrative controls will be placed on the curie content of the tanks, the temperature of incoming streams (these controls will be placed on the sending facilities), and on pump operation, to assure that the tank temperature stays within the design requirements. Plant operating experience to date at less than bounding conditions (low curie waste and low tank level) indicates that the tank temperature increases < 3°C per day with all pumps running at maximum speed and cooling water off, <1°C per day with pumps operating at maximum speed and cooling water operable, and no temperature increase with pumps off and cooling water operable. In addition, no temperature increase was observed during plant testing with cooling water off and pumps off (again, at less than bounding conditions). Monitoring of the tank liquid will be accomplished using existing temperature instrumentation which will be qualified under the backfit program. Temperature monitoring will be established as an LCO.

## 4.0 Proposed System Upgrades

Components may be installed to code of record in lieu of full safety class requirements as determined by a backfit analysis. This will allow the facility to purchase components like those already installed to provide any necessary redundancy. The upgraded systems will still perform the same function as originally designed. Relief from DOE Order 6430.1A design criteria is warranted based on backfit evaluations performed under the WSRC backfit methodology (Ref. 8). The deviations to 6430.1A safety class requirements will be documented in an assessment report and summarized in the FSAR.

### Purge/Ventilation Modification

An additional, fully redundant nitrogen-based safety class backup inerting system will be installed for Tanks 48 and 49. This system will have two independent safety trains, each with its own set of ambient vaporizers, associated piping and control valves, and sufficient cryogenic liquid nitrogen storage capacity to maintain the waste tanks inerted for four days following loss of the normal nitrogen inerting system. Each train will have the ability to be refilled to extend the supply beyond the four days, if necessary. Both nitrogen trains will be qualified to all applicable NPH criteria.

The safety class nitrogen system will not rely on electrical power for functionality. One of the two nitrogen inerting trains will be actuated and ventilation isolation interlocks activated upon detection of low primary nitrogen flow, loss of power, or seismic event (See Table 3 for interlock matrix). High tank oxygen will isolate the normal nitrogen supply which, in turn, will isolate the ventilation system and initiate safety class nitrogen. The seismic event actuation may be necessary since the primary inerting and tank ventilation systems may operate as designed, yet the tank penetrations may loosen and the tank may leak at a higher rate than the normal nitrogen flow is designed to dilute. Failure of the oxygen analyzers to detect and interlock on this condition would lead to a flammable mixture in the tanks (these monitors may not be able to be seismically qualified). A seismic trip system may be installed to eliminate the consequences due to this earthquake scenario. For high wind/tornado events, administrative controls will be implemented to shut down the process (stop benzene releases) upon tornado watch, and to take the tanks to positive pressure upon tornado warning. These actions are being used in lieu of qualifying the oxygen interlocks to meet the high wind or tornado missile criteria.

A new hardwired interlock for control of oxygen concentration in these tanks is required to prevent flammable mixtures during normal operation. This interlock will measure the oxygen concentration in the vapor space and will isolate the normal nitrogen supply (safety class function). This, in turn, will initiate safety class nitrogen, after a set delay, to take the tank to positive pressure (safety class function) and will isolate the tank exhaust flowpath through qualified isolation dampers (safety class function).

As defense-in-depth for most plant conditions, a new interlock (safety significant) will be installed for control of vapor space fuel concentration during all plant modes. This interlock will also be installed on Tank 50. The interlock will stop transfers into and out of the appropriate waste tank and stop all transfer, slurry, or filter feed pumps for the affected tank when its fuel concentration reaches 25% (indicated) of the CLFL (see Table 3 for interlock matrix).

Safety Class isolation dampers will be installed in each primary purge exhaust ventilation pathway for Tanks 48 and 49 to preserve nitrogen inerting and enable pressurization of the tank vapor space upon low nitrogen flow, low purge exhaust flow, high tank oxygen, or a seismic event. Each damper will be qualified to NPH criteria and will be fail safe. The dampers will be closed by the low nitrogen flow interlock.

Current plans are to install a cryogenic liquid nitrogen production plant for supplying normal nitrogen to the facility (including Tanks 48 and 49). Since this plant has the capability, should it malfunction, of supplying nitrogen with oxygen concentrations which could adversely impact the tank oxygen concentrations, the supply line from this plant will be equipped with oxygen monitor and isolation valve(s) to isolate the system and prevent the waste tanks from exceeding their CLOC limit. This interlock will not be safety class nor safety significant since the tank is protected by a vapor space oxygen interlock which will isolate the normal nitrogen supply on high vapor space oxygen concentration (assumptions 9, 12).

In order to prevent unnecessary challenges to the safety systems, improvements are being made to the normal tank ventilation systems for Tanks 48 and 49 to improve their reliability. These modifications include changes in the tank pressure interlock setpoint (from -0.2 in. wc. to + 0.2 in. wc.) to eliminate spurious trips due to tank pressure fluctuations or planned minor tank breach activities, supplying dry nitrogen to the purge exhaust control valve actuators to prevent spurious trips due to condensation buildup, and insulation of exhaust ductwork to reduce the impact of condensation on instrumentation which could produce spurious trips.

In addition, a program is underway to evaluate the system design to determine if there are any other modifications which would significantly improve reliability or prevent inadvertent trips. The operation of the system, including calibrations and surveillance testing, is also being evaluated for changes which would minimize downtime or spurious trips.

Vapor Space Monitoring

Tanks 48 and 49 each currently have two oxygen monitors, a benzene monitor, and a CLFL monitor installed. Tank 50 has only a CLFL monitor installed. To provide adequate monitoring of the tank vapor spaces, new oxygen and benzene monitors are being installed for Tanks 48 and 49, and a new benzene monitor will be installed in Tank 50. A set of multiple height, multiple sector sample arrays will be installed to provide multiple sampling points in the tank vapor space for each of the new oxygen and benzene monitoring systems.

The tank oxygen and CLFL instrumentation, safety class nitrogen flow monitoring instrumentation and the safety class nitrogen tank inventory instrumentation must be qualified to provide post accident monitoring capabilities, or alternate means of monitoring provided. If the monitoring cannot be qualified, the interlocks or administrative control actions must take the appropriate action to place the tanks in a safe state following the NPH event.

## 5.0 Proposed Backfits

The process of determining which systems require modification and which can be credited as currently installed is described in the Liquid Radioactive Waste Handling Facility Methodology Manual (Ref. 8). This process involves a design assessment of existing equipment against the requirements of DOE order 6430.1A, including commercial grade dedication of parts and a review for suspect/counterfeit parts. For those systems deemed inadequate by the design assessment process, quantitative risk assessments will be performed, to the extent necessary, to justify the existing design. Failure to provide an acceptable quantitative risk assessment will then result in upgrades to the current system in question.

The following set of structures, systems, and components are being considered under this backfit methodology.

Waste Tanks

The waste tanks have been analyzed and determined to retain their confinement function following small in-tank deflagrations, tornadoes and high winds, and evaluation basis earthquakes (Refs. 11, 13, 14, 15, 16). No tank modifications are expected.

Tank Level Detection

Inventory control will be established on Tanks 48, 49, and 50 to mitigate the doses due to deflagrations (and also provide overflow protection) (assumption 15). Existing level detection will be used, if possible, to maintain the inventory control. No upgrades are expected for these level indication systems (even though they are not redundant), since this control is a pre-event condition, and changes in tank level are relatively slow (maximum transfer pump capacity is 520 gpm and tanks will have a level limit that is 80,000 gallons below the TSR limit, and 500,000 gallons below the overflow limit). Additionally, experience in the tank farm indicates that indication via reel tape measurement has been sufficiently reliable. Should the high liquid level conductivity probes be chosen as the means of monitoring this parameter, the probe length must be increased and possible probe housing constructed. This would require modification to the existing instrumentation. Use of the conductivity probes would eliminate tank breaches for verifying tank level.

Slurry Pump Operations

As stated earlier, the safety class requirements for slurry pump operation are that enough pumps are available to permit liquid benzene/hydrogen depletion as a prerequisite to entering major maintenance mode for Tanks 48 and 49 and that the liquid is periodically depleted of hydrogen. Entering major maintenance mode would be necessary for major repair or replacement activities, such as a failed slurry pump. Both of these tanks has 4 pumps available, only 2 of which are necessary to effectively agitate the tank for benzene/hydrogen depletion (assumptions 2,7). Most of the repairs for these pumps can be performed without tank breach (e.g., variable speed drives), so the operability requirement will only involve those pump functions which would require removal from the tank. The minimum number of pumps will apply to Tanks 48, 49, and 50 as a normal operational requirement so that all tanks can maintain their hydrogen and liquid benzene inventory within acceptable limits. The TSR requirement for Tanks 48 and 49 will be for one more than the minimum number of operable pumps, with a sufficient amount of time in the action statements to effectively repair/replace the failed pump(s).

For Tank 50, which has only 2 slurry pumps, at least one must be operable under all modes to provide the ability to maintain liquid benzene levels within limits. Since the time to CLFL will be quite long (anticipated to be many days), repairs can be made to the inoperable pump or the pump support systems (bearing water, controls, power, etc.) in sufficient time so as not to require their classification as safety significant (assumptions 1, 2, 3, 16, 17, 18).

Interlocks/Monitoring

Several existing monitoring systems and interlocks will be credited as safety significant functions for operator protection. These include inner tank wall temperature indication, tank liquid and vapor space temperature indication, inner tank high pressure interlocks, and tank to annulus differential pressure indication. Each of these indicators and/or interlocks will be controlled under TSRs and will be included in surveillance roundsheets.

## 6.0 Assumptions

1) The benzene generation rate is strongly dependent on temperature of the tank liquid contents, and control of this temperature will minimize the degradation of NaTPB and its byproducts. This assumption is important for controlling the safety of Tank 50, as well as assuring that Tanks 48 and 49 can be maintained in a state which does not challenge the CLOC strategy and is safe for air-based mode of operation. Engineered features will be designed to prevent/mitigate events using tank temperatures which will be higher than those expected during normal operation. This assumption is being validated through the chemistry program.

2) Benzene and/or hydrogen may be retained in the liquid waste, but that which is releasable can be effectively removed through routine operation of slurry pumps or other means of agitating the tank liquids. There is sufficient evidence that both benzene and hydrogen are retained in the waste slurry to a significant degree. To control the concentration in the liquid, the slurry pumps will be run periodically so that the benzene and hydrogen can be transferred to the vapor space and purged to the atmosphere. The effectiveness of agitation and periodicity of the pump runs is being determined from the information obtained from the chemistry program. The number of pumps required to sufficiently agitate the liquid and achieve acceptable depletion is being determined through simulation and calculation. During these depletion runs, the vapor space

will be maintained in a safe state (under CLFL control for Tank 50 and both CLFL and CLOC control for Tanks 48 and 49).

3) The release rates of the benzene and hydrogen are governed by the mass transfer coefficients of the liquid waste slurries, and by molecular diffusion in the vapor space during static tank conditions (loss of ventilation and no liquid agitation). The mass transfer coefficient is low when the tank is unagitated. This assumption is being validated through the chemistry program. Administrative controls to stop all possible mechanisms of tank agitation upon loss of ventilation will limit the amount of material which would be released to the vapor space and maintain the 9 days to CLFL requirement for Tank 50 and for Tanks 48 and 49 under Major Maintenance mode.

4) The concentration of flammable materials in the tanks is highly dependent on the amount of material in the tank. The safety analysis assumes the tanks have a bounding (maximum) inventory and (minimum) vapor space volume at the time of the accident. In all likelihood this will not be the case since the tanks are not expected to be at their maximum inventories for an extended period of time. In addition, spare tank capacity requirements may further restrict the actual combined volume of Tanks 48 and 49. Actual volume limits are being determined as part of the FSAR analysis calculations.

5) A deflagration in the vapor space of Tanks 48, 49, or 50 is assumed to result in unacceptable unmitigated releases. However, conservative calculations are being performed as part of the FSAR accident analysis which may show that unmitigated doses from a deflagration do not exceed offsite limits. These calculations will assume worst-case tank inventories (maximum source term) and a stoichiometric oxygen/flammable vapor mixture (maximum release fraction). In addition, the calculations will assume that the whole vapor space deflagrates. A more likely scenario is that, upon loss of ventilation, a layer of the vapor space could be at the CLFL producing much smaller deflagrations which may not even challenge the integrity of the tank. If a deflagration were to occur which did not result in significant tank pressures, the doses would be considerably less than those being calculated in the accident analysis.

6) It can be shown that the tanks can be operated in a manner which assures that the vapor space will be below 25% (indicated) of the CLFL and that it would take at least 9 days to reach the CLFL upon loss of ventilation when under major maintenance mode for Tanks 48 and 49 and all modes of

operation for Tank 50. This is conservative since the tanks are not expected to operate at the 25% (indicated) limit, no credit is taken for the impact of moisture on the CLFL limit, and all material is assumed to accumulate in the liquid and released at a bounding rate. In reality, the potential to release large quantities of benzene is minimized because the liquid benzene in each tank will be periodically depleted by running the pumps and the tank temperature will be controlled to minimize benzene generation. The time to CLFL for Tank 50 under all modes and Tanks 48 and 49 under major maintenance mode are being determined through information from the chemistry program.

7) The liquid slurry hydrogen concentration in Tanks 48 and 49 can be maintained low enough so as not to adversely impact the CLOC value during positive pressure operation (standby mode). This assumption is being validated through the chemistry program.

8) The CLOC for Tanks 48 and 49 will be 9%, based on controls to limit the hydrogen concentration in the vapor space to less than 1.25 vol%. This value is supported by studies conducted by the Bureau of Mines (Ref. 2). Actual plant operations will maintain the oxygen concentration less than this value which will include compliance to NFPA requirements and the uncertainty of oxygen instrumentation.

9) The vapor space of Tanks 48 and 49 is adequately mixed to prevent pockets of oxygen from forming during normal operation (negative tank pressure), and to prevent flammable fuel concentrations from forming during all but standby mode of operation. Adequate mixing will be demonstrated at some nominal flowrate through each of these tanks. The determination of adequate mixing and the minimum flowrates to support this assumption will be based on an analysis of data obtained during plant testing. Additional testing may be required if current data is inconclusive. The vapor space of Tank 50 is adequately mixed during all modes of operation, but vapor space mixing is not an issue due to the low benzene concentration in the liquid.

10) Oxygen inleakage for Tanks 48 and 49 can be reduced, and those areas where significant oxygen inleakage occurs can be controlled such that the oxygen is diluted and mixed with the existing tank vapor space. This is required to prevent isolated oxygen pockets which are significantly above the bulk oxygen concentration so as not to pose a challenge to the CLOC control strategy. A plan is being developed to determine the inleakage points, seal them if possible, and inject nitrogen directly into those which cannot be sealed.

11) The inner tank pressure boundary can be qualified for all applicable events to minimize the inleakage of oxygen during normal operations (negative tank pressure) and protect the safety class nitrogen flowrate during standby operations (positive tank pressure). Qualification is part of the scheduled plant activities to support FSAR upgrade.

12) Provided the flowrate through the tank is above the minimum TSR limit, monitoring of the bulk vapor space for flammable fuel concentrations (Tanks 48, 49, and 50) and for oxygen concentrations (Tanks 48 and 49) is adequate to assure that flammable concentrations do not exist. This is predicated on the assumption that the tank vapor space is adequately mixed at the TSR limit (assumption 9). The minimum flowrate to support this assumption is being determined from plant test data.

13) Spark sources are always present when flammable fuel concentrations exist in the tank vapor space. The accident analysis assumes that a spark of sufficient magnitude is always present. A previous study (Ref. 10), applicable to Tanks 48 and 49, indicates that the chance of a spark is less than 1 in 10 for a seismic scenario. In addition, internal tank spark source have been minimized, those that exist will be in compliance with NEC requirements, and lightning dissipation systems are being added to the ITP facility. External spark sources in those areas which have a potential for significant benzene concentrations above the CLFL are being evaluated and worker safety is assured by evacuating the tank top upon tank pressurization and requiring Industrial Health and Radcon clearance to reaccess these areas.

14) Isolating the tank vapor space and injecting nitrogen at some minimum flowrate is sufficient to stop oxygen inleakage and maintain the vapor space below the CLOC. This position is dependent on maintaining a low concentration of hydrogen in the slurry prior to the event (assumption 7), maintaining inner tank integrity (assumption 11), and providing the minimum flowrate of nitrogen using safety class nitrogen. This assumption is being verified based on the results of the chemistry program and ability to qualify the tank inleakage.

15) The consequences of a tank deflagration can be minimized by limiting the curie concentration of the slurry (TSR administrative control on incoming feed), limiting the amount of material available for release (TSR limit on tank level), limiting the amount of benzene and/or hydrogen available for release to the vapor space (TSR administrative control on pump ru frequency), and limiting the amount of oxygen that can be drawn into the

tank during operations or minor maintenance mode for Tanks 48 and 49 (TSR limit on oxygen concentration). If the level is maintained sufficiently low, the release mechanism due to tank deflagrations can be limited to evaporation (versus entrainment at higher levels). This will result in significantly lower releases. In addition, controls on the liquid fuel concentrations (assumptions 2,6) and on vapor space oxygen concentration (assumption 8) provide a secondary benefit of limiting the explosive power of the vapor space, thereby limiting the amount of material that is released.

16) Limiting the amount of excess NaTPB in the tank liquid significantly reduces the amount of benzene that can be generated. This limit is being determined for the Tank 48 precipitation cycle, and will directly impact the benzene source terms for Tanks 49 and 50. This assumption is being validated through the chemistry program.

17) The rate of benzene generation from the degradation of intermediate NaTPB products is low when compared to the catalyzed degradation of NaTPB. All of these reactions are highly dependent on their liquid concentrations and on the temperature of the reaction. This assumption is being validated through the chemistry program.

18) It can be shown that KTPB and CsTPB only produce benzene from radiolytic decay. The major source of benzene is a result of catalytic generation from degradation of soluble NaTPB and its intermediate degradation products. Control of the amount of soluble NaTPB and intermediates in Tanks 48, 49, and 50, combined with control of tank temperature, is sufficient to assure a low benzene generation rate. This assumption is being validated through the chemistry program.

19) Stopping or preventing tank agitation will significantly reduce the release rate of flammable vapors. Based on plant experience, the readily releasable benzene and hydrogen are released during tank agitation, particularly during slurry pump operation. Stopping the tank agitation quickly results in a significant reduction in the benzene and hydrogen release rates. The ability to adequately deplete benzene and hydrogen is being validated through the chemistry program and through computer modeling.

20) The benzene and hydrogen release rates due to a seismic event are bounded by those from operation of slurry pump(s). This assumption needs to be validated to support the administrative control on depletion of benzene and hydrogen from the tank liquid. Calculations are being performed to validate this assumption.

## 7.0 Compensatory Actions

Since the proposed upgrades do not make all identified safety systems completely compliant with safety class requirements, it is necessary to rely upon operator actions to assure the preventive and mitigative functions operate following all DBAs. The operator actions will be identified and will be incorporated into emergency operating procedures and training.

It is recognized that the operators will respond to a given situation in different ways depending on their interpretation of the event and status of the plant at that time. Operator action can adversely affect the plant condition following a DBA, even taking credit for the proposed upgrades. These actions include starting the ventilation fans without normal nitrogen supply operable, stopping the safety grade nitrogen supply during positive pressure operation in the tanks, stopping ventilation flow when in air based operation, and bypassing critical interlocks. To provide assurance that operators do not impact the safety functions of the upgraded systems, all abnormal and emergency operating procedures and training programs will stress that, when in operation of standby modes for Tanks 48 and 49, the only system that must function following an event is the safety grade purge system, and that all efforts should be made to ensure this is functioning properly prior to any other actions. In addition, if in major maintenance mode for Tanks 48 or 49, or at any time for Tank 50, the verification and reestablishment of ventilation flowrate (if necessary) is the only immediate safety action necessary. All actions will be identified in appropriate emergency or abnormal operating procedures.

The proposed upgraded systems do not prevent the Tank 48 or 49 sequence of deflagrations during air-based operation. Administrative controls (TSRs and procedures) will be placed on the conditions for entering this mode of operation, such as depletion of benzene in the liquid to support adequate time to reestablish CLOC control prior to reaching CLFL under subsequent loss of ventilation, or adequate time to reestablish air-based ventilation prior to reaching the CLFL. Operational limits will be enforced during air-based operation and air-based operation itself will only be allowed for limited periods of time. During air-based operations, operation of the slurry pumps will not be permitted to reduce the potential to release large quantities of benzene into the vapor space. Control of additions or transfers to the tanks is required during this mode of operation to assure that the benzene generation and release is minimized. Because of the limited amount of time that the facility will be allowed to operate the tanks in the air-based mode, the window of risk for having a seismic event at this time is considered to be small.

8.0 References

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Table 1

Proposed Modifications

Safety Class Tank Inerting System (Tanks 48, 49) - NPH qualified

* Two liquid nitrogen tanks and ambient vaporizers
* Interconnecting piping, valves, and instrumentation
* Control valves and flow indication on lines to tanks
* Fail safe interlocks to initiate system on low nitrogen flow

Tank Ventilation System (Tanks 48,49)

* NPH qualified exhaust isolation dampers
* Fail-safe interlocks to actuate exhaust dampers on low purge exhaust flow, low nitrogen flow, high tank oxygen concentration, and seismic event
* Seismic Modifications to existing ductwork, etc.
* NPH qualified isolation valves for normal nitrogen supply
* Fail-safe interlocks to actuate safety class nitrogen supply valves on low normal nitrogen flow, low purge exhaust flow, high tank oxygen concentration, and seismic event

Tank Monitoring

* New oxygen monitors in Tanks 48 and 49
* New benzene monitor in Tanks 48, 49, and 50
* Means to monitor tank vapor space (oxygen and benzene) at multiple locations
* Interlock to stop transfer, slurry and filter feed pumps on high vapor space CLFL (also includes ITP Filtrate Hold Tank and Late Wash filtrate hold tank pumps for Tank 50)

Tank Containment (48 and 49 only)

* Determination of leak points and sealing or injecting nitrogen

| SSC/Admin Control | Safety Function | Status | Proposed Classification | Current Classification | Mode of operation | Applicable Plant Area |
|---|---|---|---|---|---|---|
| **Vacuum break/pressure relief valves** | Maintain pressure boundary to minimize oxygen inleakage and protect nitrogen flowrate and inventory | Backfit | SC | CP | All modes | 48,49 |
| **Tank cooling coils** | Seismic qualified to prevent siphoning events or inadvertent water addition | Backfit | SC | CP | All modes | 48,49,50 |
| **Tank Wall Temp. probe & operator rounds** | Determine if tank wall approaches 10°C to prevent brittle failure | Backfit | SS | PS | All modes | 48,49,50 |
| **Tank Level Indicator and operator rounds** | Mitigation for deflagration events (<880K gal) | Backfit | SS | CP (PS if reel tape is used) | All modes | 48,49,50 |
| **Tank Temp. indicator & operator rounds** | Ensure tank temperature is below value assumed in benzene generation calculations | Backfit | SS | PS | All modes | 48,49,50 |
| **Inner Tank pressure boundary** | Contain material; provide flowpath for air dilution | Backfit | SS | CP | All Modes | 50 |
| **Tank annulus** | Contain leaks from inner tank and provide capability of detecting leaks prior to catastrophic failure | Backfit | SS | CP | All modes | Tanks 48,49,50 |
| **Tank annulus leak detection** | Detect leakage from inner tank and alarm for operator action | Backfit | SS | CP for 48,49<br>PS for 50 | All modes | 48,49,50 |

Table 2 - Safety Functions and [illegible]ems Credited

| SSC/Admin Control | Safety Function | Status | Proposed Classification | Current Classification | Mode of operation | Applicable Plant Area |
|---|---|---|---|---|---|---|
| **Tank primary to annulus Delta Pressure gage** | **Protect inner tank failure due to excess pressure differential between annulus and inner tank** | **Backfit** | SS | CP | All modes | 48,49,50 |
| **CLFL Monitor (non-NPH)** | **Ensure vapor space concentration is below CLFL** | **Backfit** | SS | CP | All Modes | 48,49,50 |
| **Seismic Trip (If oxygen monitors cannot be qualified)** | **Trip tank 48 and 49 isolation valves and initiate safety class nitrogen** | **New** | SC for 48,49 | | All modes | 48,49 |
| **CLFL interlocks (Non-NPH)** | **Stop transfer, slurry, filter feed pumps and washwater additions if benzene >25% CLFL** | **New** | SS | | All Modes (admin controls during major maintenance) | 48,49,50 |
| **Slurry pumps** | **Minimum number must be operational to achieve and/or maintain low liquid benzene inventory and hydrogen inventory (support systems are GS)** | **Backfit** | SC | GS | Operation Mode | 48,49,50 |
| **Inner Tank pressure boundary** | **Contain material; minimize oxygen inleakage, protect nitrogen flowrate & capacity** | **Backfit, may need seismic analysis for inleakage** | SC | NS | Operation Mode | 48,49 |
| **Inner Tank pressure boundary** | **Maintain negative pressure control** | **Backfit** | SS | NS for 48,49, CP for 50 | Operation, minor and major maintenance modes | 48,49,50 |
| **Low exhaust flow interlock** | **Isolate normal nitrogen supply to minimize tank pressurization** | **Upgrade** | SS | PS | Operation, minor and major maintenance modes | 48,49 |

Table 2 - Safety Functions and Systems Credited

| SSC/Admin Control | Safety Function | Status | Proposed Classification | Current Classification | Mode of operation | Applicable Plant Area |
|---|---|---|---|---|---|---|
| High tank pressure indicator | Alert operations to evacuate areas which may become hazardous(tank top, lab, valve boxes, etc.) | Upgrade | SS | CP | Operation, minor and major maintenance modes | 48,49 |
| Low nitrogen flow interlock | Stop transfer, slurry, and filter feed pumps to minimize benzene release | New | SS | | Operation, minor maintenance modes | 48,49 |
| Low Nitrogen Flow Interlock | Isolate ventilation and initiate safety grade nitrogen | New | SC | | Operation, minor maintenance modes | 48,49 |
| Tank vapor space Oxygen Monitor and interlock to isolate and pressurize tank | Ensure tank vapor space oxygen concentration <MOC | New | SC (non-NPH) | | Operation, standby, minor maintenance modes | 48,49 |
| Ventilation isolation damper | Isolate ventilation under low of nitrogen flow, low purge exhaust flow, or high oxygen | New | SC | | Operation, standby, minor maintenance modes | 48,49 |
| Safety grade nitrogen systems | Provide inerting to maintain MOC control | New | SC | | Standby Mode | 48,49 |
| Portable Ventilation systems | Provide ability to maintain vapor space below CLFL following loss of ventilation | Backfit | SC | NS | Major maintenance mode | 48, 49 |
| Portable Ventilation systems | Provide ability to maintain vapor space below CLFL following loss of ventilation | Backfit | SS | NS | All Modes | 50 |

Table 2 - Safety Functions an tems Credited

Table 3

Interlock Matrix

| | Initiate SC N2 (48 & 49) | Isolate Normal N2 (48 & 49) | Isolate Exhaust (48 & 49) | Trip Pumps[a] | Trip Purge Exhaust Fans(s) |
|---|---|---|---|---|---|
| Lo Normal N2 Flow (48 & 49) | SC | SC | SC | SS | PS |
| Lo Exhaust Flow (48 & 49) | | SS | | | |
| ***HI O2 (48 & 49)*** | | ***SC***[b] | | | |
| ***HI CLFL (48, 49 & 50)*** | | | | ***SS***[c] | |
| Loss of Power (48, 49 & ***50***) | SC | SC | SC | SS | PS |
| ***Seismic (48 & 49)*** | | ***SC***[b] | | | |
| Hi Tank Pressure (48 & 49) | | SS | | | |

Notes:

a. Tank 48 - Transfer Pumps (Tk ***42***, 48, ***49 & 50***), Slurry Pumps (4), FFPs (2)
Tank 49 - Transfer Pumps (Tk ***48*** & 49), Slurry Pumps (4)
***Tank 50 - Transfer Pump (Tk 50), FHT Pumps (2), LWHT Pump, Slurry Pumps (2)***

b. O2 interlock function is Safety Class. Seismic interlock provides seismic protection if O2 monitor can't be seismically qualified. High wind/tornado/missile protection to be provided by administrative control.

c. Interlock for Tank 48 also closes wash water isolation valve.

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