CSTF PROGRAM DESCRIPTION DOCUMENTS (PDDs)

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CSTF Corrosion Control Program

Program Description Document

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SUMMARY OF REVISIONS

Revision	Date	Description
9	12/15	Deleted references to Mechanical Cleaning Mode consistent with DSA 2015 Annual update. Added requirements for Tank 48. Added sample frequency for Sludge and Salt Feed Tanks to Table 8. Clarified requirements for tanks that are noncompliant for chemistry. Added DSA statement regarding analytical uncertainty.
8	2/28/14	Revised to comply with Manual S4 Procedure ENG.36 and corrected document references. Added requirements for salt dissolution processing, high hydroxide temperature limits, out of service evaporator tube bundles, noncompliant ventilation requirements, structural integrity requirements for tanks out of chemistry compliance, and video inspections for dry salt tanks. Added equation to calculate dilute chemistry temperature limit below 40 ºC. Removed Slurried Waste Tank designation requirements. Added annulus conductivity probe level requirements.
7	2/13	Incorporated changes to Closure Mode and deleted references to Removed From Service Mode, consistent with DSA Change Request HLW-CRF-12012, Rev. 0, Type I/II/IV Waste Tank Grouting. Added clarification for Acidic Chemical Cleaning that concentrations of acid between 4 wt% and 8 wt% are subject to the requirements of 8 wt%.
6	8/12	Established requirements for Chemical Cleaning of Type I and II Waste Tanks in H and F Tank Farms (excluding Tank 1, 5, and 6) consistent with DSA Revision 14. Updated the Vapor Space Corrosion section based on assessments and experimental testing performed by SRNL. Defined vapor space corrosion control requirements for Type III/IIIA tanks.
5	2/12	Defined the Corrosion Program Life Cycle Stages and associated DSA Waste Storage Tank Mode designation, Closure and Removed-from-Service Mode and established corrosion controls. Established minimum wall temperature limits for Operations,

		Gas Release, Closure, and Removed from Service Modes. Clarified the requirements for functional thermocouple for tanks undergoing the closure process.
4	12/10/07	Corrected constants in equations to calculate NO2 inhibition requirements for dilute nitrate solutions. Clarified how the steel wall thermocouples are verified to be within 3 feet of the bottom knuckle weld. Deleted the words, "If available and to extent practical," to clarify Section 3. Requirement frequencies were changed to days vice months and years. The PDD was clarified that components other than waste transfer lines (e.g., waste tanks) were looked at for MIC concerns. The PDD was revised to identify the available margins and sample accuracy based upon technical report, X-ESR-G-00010. Corrected Table 6 and Table 6 notes. Program direction for tanks declared as closure waste tanks. Reordered References
3	11/17/04	Addition to allow 30 day grace period for sample frequency and time allowance for sample analysis and results incorporation into WCS; Addition of sample analysis tracking in the ERD.
2	5/7/03	Addition of wording to allow engineering evaluations to extend the 45 day limit on restoring chemistry in a waste tank. Change to Table 6 to better clarify meaning; Rewording of sentences describing temperature monitoring to show that evaporator drop tank's supernate phase temperature monitoring has been excluded.
1	3/5/03	Addition of "Sampling Methodology" reference [75]; new wording regarding output documents.
0	2/14/03	Initial Issue

GLOSSARY OF TERMS

Active Waste Tank – a tank that has received a waste transfer within the past 365 days, is available to receive a waste transfer at any time, or is being slurried.

Bulk Waste Removal Tank (BWR)- a tank undergoing mixing processes designed for the ultimate removal of sludge from the tank inventory.

Caustic Stress Corrosion Cracking (SCC) – cracking due to sodium hydroxide concentration, stress and temperature.

Cleaning Activities Life Cycle – A tank (Type I, II and Type IV Waste Storage Tanks) preparing for operational closure. A tank enters the Cleaning Activity Life Cycle Stage when it is undergoing the final phases of waste removal including bulk sludge removal, bulk salt dissolution, chemical cleaning, cooling coil flushing, and annulus cleaning. When a tank is declared to be in the Cleaning Activity Life Cycle Stage, chemistry limits and sampling requirements specified in this Program Description Document are suspended or modified for a specified length of time.

Closed Waste Tank – A tank that has been grouted and support systems removed.

Dry Waste Tank – a tank that contains salt and/or sludge, but has an inadequate amount of free supernate to allow sampling for analysis

ERD – Emergency Response Datasheet (N-ESR-G-00001)

Final Stabilization Preparation Life Cycle – A tank going through the regulatory approval process for final stabilization. Active corrosion protection for waste storage tanks in the final stabilization preparation stage is not required and the tank is removed from the Corrosion Control Program. Tanks in this life cycle are Closure mode tanks as defined by the DSA. Administrative controls require the tank be stabilized within 10 years; any return to service shall be authorized only by engineering evaluation(s) ensuring the integrity of the tank is sufficient to meet the intended return to service DSA mode designation.

Inactive Waste Tank – a tank that has not received or sent a waste transfer within the past 365 days, nor is in the process of being mixed.

Nil-Ductility Transition Temperature (NDTT) a temperature below which a metal loses ductility and becomes brittle and may be subject to failure due to brittle fracture.

Nitrate SCC – cracking due to sodium nitrate concentration, stress and temperature.

Normal Operation Life Cycle – Corrosion protection for waste storage tanks in normal operation is optimized to minimize the risk of a leak site or loss of structural integrity for the time frame that the tanks remain in this life cycle.

Normal operation activities include storage, sludge/salt preparation, bulk sludge removal, and bulk salt dissolution.

Pitting – an extremely localized intense form of corrosion that may result in perforation with only a small amount of general wall thinning of the structure. Failures often occur suddenly.

Receiver Waste Tank – an active tank that is not slurried, undergoing salt processing, nor is an evaporator feed or drop tank.

Salt Feed Tank – a tank in which the chemistry has been qualified for salt waste processing. No additional waste transfers in are allowed until the next qualified batch.

Salt Processing Tank – a tank undergoing processes designed for the ultimate removal of salt from the tank inventory (eg., salt dissolution, interstitial liquid removal, etc.)

Stress Corrosion Cracking (SCC) – cracking caused by the simultaneous presence of tensile stress, a specific corrosive medium, and sufficiently high temperature

Sludge Feed Tank - a tank in which the chemistry has been qualified for sludge batch processing. No additional waste transfers in are allowed until the next qualified batch.

WCS – Waste Characterization System

Vapor-Space Corrosion – Vapor-Space corrosion is general or localized corrosion that may occur in the vapor space due to conditions created by relative humidity and the behavior of aggressive species to adsorb humidity, potentially forming localized aggresive solutions.

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1.0 Scope

The scope of the Concentration, Storage, and Transfer Facilities (CSTF) Corrosion Control Program Description Document (PDD) is to provide guidance to Engineering personnel for implementing corrosion related controls for waste tanks, cooling coils, evaporator tube bundles and waste transfer systems.

2.0 Purpose

The purpose of the Corrosion Control Program is to ensure that corrosion of safety related equipment in the tank farms is managed for general corrosion, stress corrosion and pitting corrosion, so as to preserve the integrity of each component for its service life as mandated by the Documented Safety Analysis (DSA). This Program Description Document shall conform to the requirements of S4 Manual Procedure ENG.36.

3.0 Background

3.1 *Safety Function*

The safety function of the CSTF Corrosion Control Program is to ensure that the waste tanks, evaporator tube bundles, waste transfer systems and cooling coils are managed for all applicable corrosion mechanisms to preserve the integrity of each component for its service life. Most of the controls listed in this document deal solely with the condition of a waste tank; however, since this program controls the chemistry and temperature of all waste in the tank farms, it protects all safety-related equipment in the tank farms' transfer paths from corrosion. In addition, controls are listed which protect the evaporator tube bundle in the event the tube bundle is not covered by waste.

This program does not apply to "Closed" tanks

3.2 *Key Attributes*

In order to protect the safety-related equipment, there are several attributes of this program that are necessary for tanks that are not designated as Closure Mode tanks as defined by the DSA; they are as follows:

1. Temperature

The corrosion control program sets temperature limits, to ensure that the risk of corrosion degradation is minimized.

- Based on tank chemistry
- Specific for each tank constituent (i.e., sludge/salt, supernate, and steel wall)

- Temperature is periodically checked using representative thermocouples placed in various places in each waste phase within the waste tanks

2. Chemistry

The corrosion control program requires minimum concentrations of inhibitor to be present for corresponding amounts of corrosive species in waste to prevent corrosion.

- Actual tank chemistry is obtained through periodic sampling – sampling schedule based on tank chemistry / use of tank is specified by the program
- Tank-to-tank transfers are evaluated to ensure chemistry is kept within limits
- Water Additions to Waste Tanks – the corrosion control program sets limits on how much water can be added to a waste tank over certain time intervals based on the concentration of the inhibitor in the tank
- Microbiologically Induced Corrosion (MIC) – this program addresses the potential for and lists mitigating actions to preclude MIC.
- Evaporator Tube Bundles – this program ensures that the evaporator tube bundles are kept from conditions that would lead to corrosion.
- Chromate Cooling Water – this program outlines the method to minimize the failure of cooling coils due to corrosion from the interior of the coil.

3. Humidity

The corrosion control program requires the operation of annulus ventilation in order to keep the annulus dry unless the tank is in the Cleaning Activities or Final Stabilization Preparation Life Cycle [1].

- Steam is supplied to the pre-heater so that dry air is circulated through the annulus.
- A conductivity probe, or an acceptable alternate (e.g., dip tube), in each annulus alerts operations if any liquid is detected in the annulus
- **Annulus ventilation is a credited control imposed by the Flammability Control Program.**

The parameters defining the Corrosion Control Program for Closure Mode Waste Storage Tanks are documented in Chapter 5 of the DSA.

3.3 *Evaluations*

The output documents generated by this PDD shall ensure independent verification or validation of results and conclusions. Output documents include, but are not limited to, calculations, procedures and technical reports.

Grace periods are allowed for operational flexibility. Good operating practice would dictate that grace periods are not to be relied upon as routine extensions of the specified interval.

Calculations issued as output documents shall be confirmed Type I calculations in accordance with the requirements of the E7 Manual, Procedure 2.31A. Technical Reports issued as output documents shall comply with the requirements of E7 Manual, Procedures 3.60 and 2.60. Additionally, the output documents will be assessed in accordance with Manual 11Q, Procedure 1.05 as applicable.

Proposed deviations from compensatory actions and monitoring requirements as described in this PDD shall conform to the requirements of S4 Manual Procedure ENG.36.

3.4 *Bases for Criteria*

The Corrosion Control Program is included in a list of general controls in Section 3.4.1.5.6 of the DSA. The initial Corrosion Control Program, established in G-TRT-G-00003, Appendix 6 [2], has been preserved in this document, although the means of implementation have been changed slightly.

The time limits given for the completion of a compensatory action or the monitoring frequency are all based on the desire to stop the initiation of corrosive reactions when possible and retard corrosion if it is initiated, while at the same time realizing the time needed to perform various corrective actions. Since the end results of corrosion are grave, the corrective actions to remove an environment conducive to corrosion from the CSTF must be pursued with speed and diligence. With this philosophy in mind, the time limits were established, based on the estimated time that various actions could reasonably be performed.

Corrosion is a comparatively slow phenomenon and limits are based on general chemistry regimes without distinctive thresholds between them. Thus, use of nominal values is acceptable and does not need to include analytical uncertainty.

4.0 Program Description

The Corrosion Program consist of three life cycle stages: (1) Normal Operation, (2) Cleaning Activities, and (3) Final Stabilization Preparation. Corrosion controls and the applicable DSA waste storage tank mode of operation are defined for each life cycle stage below. The change from one Life Cycle to the next is initiated by a request from the Project Manager in support of Tank Closure activities. The Life Cycle initiation and expiration dates will be tracked in the ERD.

Table 1- Corrosion Program Life Cycles and Controls.

Corrosion Life Cycles	Process Activities	DSA Waste Tank Modes	Temp Min	Temp Max	Chemistry	Annulus Ventilation	Sampling	Time Limits
Normal Operation	1. Storage 2. Sludge/Salt Preparation 3. BSR 4. BSD	1. Gas Release 2. Operations	Yes	Yes	Yes	Yes	Yes	No
Cleaning Activities	1. BSR 2. BSD 3. Chemical Cleaning 4. Waste Tank Annulus Cleaning	1. Gas Release 2. Operations	Yes	Yes	No	No*	No	Yes
		3. Acidic Chemical Cleaning 4. Non-Acidic Chemical Cleaning	No	Yes	No	No*	No	Yes
Final Stabilization Preparation	1. Regulatory Approval Process 2. Tank Grouting	1. Closure	No	No	No	No	No	Yes

Notes:

1. BSD = Bulk Salt Dissolution
2. BSR = Bulk Sludge Removal
3. Temperature Minimums are related to Nil Ductility Transition Temperature

***Annulus ventilation is a credited control imposed by the Flammability Control Program**

4.1 *Normal Operations Life Cycle*

Corrosion protection for waste storage tanks in Normal Operation is optimized to minimize the risk of a leak site or loss of structural integrity for the time frame that the tanks remain in this life cycle. Normal operation activities include storage, sludge/salt preparation, bulk sludge removal, and bulk salt dissolution. Applicable DSA designations include Gas Release and Operation Modes.

Any activity carried out in a waste tank or other equipment that is not designated for operational closure is considered normal operations. The integrity of these structures, systems, and components (SSC) must be maintained to support the mission of the CSTF; therefore the most restrictive corrosion controls are implemented to protect the service life of these SSCs.

4.1.1 TEMPERATURE

Temperature limits were established to ensure that the risk of corrosion degradation is minimized based on tank chemistry. Temperature is periodically checked using representative thermocouples placed in various places in each waste phase within the waste tanks.

Maximum temperature limits were established for each specific waste phase (supernate and sludge/salt) and tank steel wall. The uncertainty in the limit and temperature measurement is addressed by lowering; (1) the high operating limit 4 ºC less than the ERD temperature requirements when the ERD limit is greater than 55 ºC and (2) lowering the high operating temperature limit 3 ºC less than the ERD temperature requirement when the ERD limit is less than 55 ºC [76]. The supernate temperature limits were established to prevent the initiation of stress corrosion cracking and pitting of the tank walls and cooling coils and to minimize the propagation of existing cracks. The maximum salt/sludge and steel wall temperature limits were established to maintain a liquid phase, which contains sufficient corrosion inhibitors, in continuous contact with the tank wall. The temperature limits dictated by this program are more restrictive than those required to maintain the structural and leak integrity of the tank [3], although other factors may necessitate even lower temperature limits.

The basis for the temperature limits is discussed in-depth in Reference 4. In order to ensure temperature monitoring is available, the Corrosion Control Program requires that there be at least one functional thermocouple (TC) to monitor each applicable waste phase and the steel wall for waste tanks, **with the exception of the supernate phase in evaporator drop tanks.** For Normal Operations, the TC monitoring the steel wall temperature for Type I, II, and III tanks must be within three feet of the bottom knuckle weld (this requirement is not applicable to Type IIIA or IV tanks).

Minimum tank wall temperature limits were established to minimize the risk of low temperature embrittlement of the carbon steel tank wall by maintaining the temperature above the nil ductility transition temperature (NDTT). Brittle fracture is not an issue for Type IV tanks because these tanks are not free-standing, but built into a concrete support structure with no annulus. Thus, no potential for rapid change of the steel temperature due to contact with cold outside air exists. Minimum tank wall temperatures limits are shown in Table 2.

Introducing a New Supernate Phase

When a new supernate phase is established in a sludge or salt tank, the requirement to have at least one functional TC for the new supernate phase shall be met within 5 days after sufficient liquid has been added to the tank to cover the lowest available thermocouple. The determination that sufficient liquid has been added to cover the lowest available thermocouple (and therefore the 5-day period to perform the monitoring has started) may be made by direct measurement of tank liquid level or by evaluation of liquid volumes added to the tank (e.g., from tanker trucks, IW tank, waste transfer).

There is no requirement to stop liquid additions at the point where the lowest thermocouple is just under the liquid surface in order to perform applicable monitoring. It is preferable to continue liquid additions until a process-related stable stopping point is reached. Filling the tank with several hundred thousand gallons (as part of the initial addition or a subsequent addition) prior to performing the applicable thermocouple monitoring is acceptable as long as temperature of the liquid added is below the supernate temperature limit expected to exist after the additions.

Supernate Temperature Limits for Concentrated Supernate ($NO_3 \geq 1$ M)

The recommended supernate temperature limits in Table 3 are for concentrated wastes (i.e., nitrate concentration greater than 1 molar) and are dependent on the molar concentration ratio (R) of the inhibitor species (e.g., nitrite and hydroxide) to the corrosive species (e.g., nitrate). For concentrated wastes, the ratio (R) of the hydroxide and nitrite concentrations to the nitrate concentration was observed to be an indicator of waste corrosivity [5]. Stress corrosion cracking is the primary degradation mechanism for this case. From Table 3 it is shown that the two limits are 70°C when R is less than 2.0 (except when the nitrate concentration is between 2.75 M and 5.5 M, then the lowest boiling point temperature in that range is the limit) and the boiling point when R is greater than or equal to 2.0. These limits are based on extensive laboratory testing and analysis of process history [6]. Due to the various waste tank compositions, the boiling point temperature differs from tank to tank. However, over a significant concentration range the boiling point differs by only a few degrees. An equation was developed to calculate the boiling point given the total molarity of the waste [6].

$$T_{bp}\,(^{o}C) = 100 + (\text{total molarity})*1.03°\text{C-liter/mole} \qquad (1)$$

For cases where R was greater than 2.0, the equation was utilized to determine the average boiling point for the nitrate concentration ranges 1 to 2.75 molar and 2.75 to 5.5 molar. The 5.5 to 8.5 molar nitrate concentration range was not considered due to solubility limitations. The boiling point was calculated in the following manner. It was assumed that since the primary components of the waste were nitrate, nitrite, and hydroxide, that the sum of these three molar concentrations could be utilized to determine the total molarity. The boiling point temperature was first determined at the lower end of the concentration range assuming that R was 2. For example, if the nitrate concentration is 1 molar, the sum of the hydroxide and nitrite concentrations would be 2 molar, and thus the total molarity would be 3 molar. Substituting this value into Equation 1 gives a calculated boiling point of 103°C. Performing a similar calculation using a nitrate concentration of 2.75 M, an estimated boiling point of 108°C is obtained. The average of these two temperatures is 105°C. A temperature of 105°C was determined to be an acceptable limit for wastes within this supernate

concentration range. The same assumptions and calculations were made for the nitrate concentration between 2.75 to 5.5 M. In this case the average estimated boiling point was 112°C.

Supernate Temperature Limits for Concentrated Supernate (OH ≥ 8M)

During the evaporation process, the sodium hydroxide, sodium nitrate, sodium nitrite and other non-volatile constituent concentrations are increased. Sodium nitrate and sodium nitrite saturation is reached and crystallizes as saltcake in the evaporator drop tanks. The evaporator systems' feed is usually high in hydroxide, and therefore as the evaporation/recycle process continues the concentration of hydroxide in the system increases. It is not unusual to observe hydroxide concentrations in the evaporator systems above 8 molar and sometimes as high as 12 molar.

Testing was performed to establish significant independent variables affecting the corrosion process with different chemical, atmospheric and temperature regimes modeling the Tank Farm evaporator system. The test results indicated that the most important factors affecting corrosion of the steel are the solution temperature and hydroxide concentration [Ref. 75]. No evidence of caustic SCC or general corrosion in the laboratory specimens indicate that Type III/IIIA nuclear waste tanks are not susceptible to corrosion in highly caustic solutions up to 12 M hydroxide at 125ºC when there is sufficient sodium nitrite (≥0.3 M) inhibitor present and the T-ratio ($[OH/([NO_{3-}]+[NO_{2-}])$) is less than or equal to 10, therefore limiting the temperature limit to 115 ºC is conservative (See Table 3).

Sludge/Salt/Steel Wall Limits (NO_3 ≥ 1 M)

The temperature limits (see Table 4) for the salt and sludge phases (T_{ss}) and the steel wall (T_w) are based on maintaining a liquid phase, containing inhibitors, at the tank wall. The composition of the interstitial liquid in the salt and/or sludge, and hence the liquid which is in contact with the bottom and wall of the primary, is not completely known. However, laboratory tests and analysis of actual interstitial liquid have shown that for saltcake the R ratio is much greater than 2 [7]. The interstitial liquid present in sludge has also been characterized [8]. In general, the nitrate concentration in the supernate above the sludge was greater than that observed in the sludge interstitial liquid. It is likely that the nitrate concentration decreased due to ionizing radiation that converts the nitrate to the inhibitor species nitrite. Thus as the sludge ages, the R factor of the interstitial liquid increases indicating a decrease in the corrosivity of the liquid. For these reasons the temperature limits for the salt/sludge and the steel wall is the boiling point for a particular waste concentration.

The tank steel wall temperature limits apply to Type I, II, III and IIIA tanks. If the waste temperature were greater than the solution boiling point, it would be possible to produce nitrate-rich salt deposits on the tank wall [9]. As the waste ages and cools, there could be gradual intrusion of water vapor or supernate into the deposit. The resulting solution may have high local concentrations of nitrate ion. The effects of this condition on either nitrate or hydroxide stress corrosion

cracking cannot be predicted or simulated because of its complexity. Maintaining solution temperatures below the calculated maximum temperature limits prevent the occurrence of this phenomenon.

The static head of the waste above the location of the thermocouples that measure T_{ss} and T_w elevates the boiling point temperature above the atmospheric supernate boiling point temperature [10]. The boiling point temperature elevation is calculated on the basis of the volume and the specific gravity of the waste in each tank [11]. The Clausius-Clapeyron equation relates the boiling point elevation to the static head pressure due to the liquid depth. In general, most of the concentrated wastes (nitrate > 1 molar) have a specific gravity greater than 1.25. If a tank contains 120 inches of free supernate, the total pressure at a level 120 inches below the top of the supernate due to the liquid head, assuming a specific gravity of 1.25, is 20.1 psia. Substituting this pressure into the Clausius-Clapeyron equation, a boiling point elevation of 10°C is calculated. Therefore, it is recommended that the temperature limit for T_{ss} and T_w be determined not only by the supernate boiling point temperature but also the depth of free supernate. If the depth of free supernate is greater than 120 inches, the temperature, T_{ss} and T_w, limits shall be 10°C greater than the boiling point of the supernate. Depending on the composition of the supernate, these temperatures would be either 115°C or 122°C. If the depth of free supernate is less than 120 inches, T_{ss} and T_w limits shall remain the same as the boiling point of the supernate. In many cases, this is a conservative approach (i.e., the boiling point is actually higher) as the amount of free supernate in a tank is much greater than 120 inches. If the temperatures measured by the thermocouples rise to near these boiling point values, a more rigorous calculation should be performed. This calculation would involve determining the exact position of the thermocouple relative to the waste level. The boiling point elevation can be determined accurately from the Clausius-Clapeyron equation. The simplified approach to be implemented eliminates the difficulty of determining the elevation difference between the top of the supernate and the thermocouple that is being utilized to measure the temperature.

Supernate and Sludge/Salt/Steel Wall Temperature Limits for Supernate with Low Nitrate Concentrations (NO_3 < 1 M)

At nitrate concentrations less than 1 molar the predominant corrosion mechanism is pitting. There are two regions of the tank where pitting is a concern. The first region occurs at the vapor/liquid interface. Here a thin wetted film forms on the tank wall above the liquid level [12]. This film absorbs carbon dioxide that reacts with the hydroxide to form carbonate and bicarbonate. Unless there is sufficient hydroxide or nitrite in the bulk waste to replenish this film with inhibitors by diffusion processes, this layer becomes uninhibited and pitting results.

The second area is in the walls in contact with the bulk liquid. Depletion of hydroxide is slower in the bulk liquid than for the thin film, however, given enough time it will occur here also. Tanks that have a small volume of waste or

low hydroxide concentration are most susceptible to inhibitor depletion [13]. The temperature limits are summarized in Table 5.

There are two schemes for inhibiting nitrate induced pitting: 1) sodium hydroxide addition alone, or 2) the addition of sodium nitrite with a minimum hydroxide level. If the hydroxide concentration is greater than 1 molar the sodium hydroxide scheme has been selected. Laboratory tests have shown that no pitting is observed in simulated dilute waste that contains greater than 1 molar hydroxide [14, 15]. A theoretical model also demonstrated that a minimum hydroxide concentration of 1 M is sufficient to maintain a minimum pH of 12 in the wetted film region [12].

At high hydroxide concentrations stress corrosion cracking may become a concern. In hot caustic solutions carbon steel may become susceptible to caustic stress corrosion cracking. Laboratory testing was performed in simulated wastes that contained between 1 to 8 molar sodium hydroxide, 0.02 to 1.0 molar sodium nitrate, and at temperatures between 50 to 100°C [16, 17]. The results of the tests demonstrated that the presence of a small amount of nitrate was enough to prevent caustic cracking within these environmental conditions. If less than 0.02 molar nitrate is present there is a potential for caustic cracking at high temperatures. Therefore, for nitrate concentrations less than or equal to 0.02 molar the temperature limits were set at 60°C. If the hydroxide concentration exceeds 8 molar, the carbon steel may again become susceptible to caustic stress corrosion cracking. Therefore, for this case, the temperature limits are also 60°C. Otherwise a temperature of 100°C may be utilized for the temperature limits. The temperature limits for tanks that meet these hydroxide concentration conditions were based on the criteria that the liquid would always have sufficient inhibitor to prevent attack at temperatures less than 40°C. The establishment of these corrosion inhibitor concentration criteria determines when inhibitor additions shall be performed.

The 40°C temperature is sufficiently above the normal operating temperature (i.e., 18 to 32°C) of the tanks which contain dilute waste, while at the same time not resulting in the addition of excess inhibitor. It is recognized that the chemistry in a waste tank may change (become more dilute) based on the processing activities (e.g., sludge/salt preparation, bulk sludge removal, bulk salt dissolution) occurring in the waste tank and/or storage requirements for the waste tank. For <u>dilute</u> waste streams (NO3 < 1M), the maximum supernate temperature can be revised based on the inhibitor ratio models [4, 19] below to ensure sufficient temperature controls are applied for the waste composition to ensure that it protects all safety-related equipment in the tank farms' transfer paths from corrosion. Revising the supernate temperature limit ensures the safety function of the program is met for managing corrosion and is within the bounds of the DSA.

$$\text{Temperature Limit} = \text{Log}([NO2]/[NO3]/0.038)/0.041 \qquad (2)$$

The primary aggressive species in dilute solutions is the nitrate anion [18], although at very dilute nitrate concentrations, the chloride or sulfate ion may

become the aggressive species [19]. There are four possible conditions in the dilute waste: 1) the waste has nitrate concentrations less than 0.02 molar, 2) nitrate is the aggressive species, 3) chloride is the aggressive species, and 4) sulfate is the aggressive species. From these equations the minimum ratio of the nitrite to aggressive species can be calculated for a waste at 40°C. These ratios and the constant values for each condition, MIN, are shown below for all Tanks excluding Tank 48.

NO_3 <0.02 M: $[NO_2^-] = 0.033$ (3)

Nitrate: $[NO_2^-]/[NO_3^-] = 1.66$ (4)

Chloride: $[NO_2^-]/[Cl^-]^{1.34} = 267$ (5)

Sulfate: $[NO_2^-]/[SO_4^{-2}]^{0.84} = 1.75$ (6)

Tank 48 MIN concentrations are as following [78]:

Nitrite: $[NO_2]/[NO_3]^{0.79} = 0.91$ (7)

Chloride: $[NO_2]/[Cl]^{1.03} = 32$ (8)

Sulfate: $[NO_2]/[SO_4]^{0.61} = 0.90$ (9)

A review of these equations showed that if any one of these requirements is violated, then inhibitor shall be added to the waste or the maximum supernate temperature limit must be adjusted if applicable. The maximum value obtained from these equations determines the minimum nitrite. The amount of nitrite added to the waste shall correspond to the value from the equation in which the requirement was violated, or if more than one requirement was violated, the value from the equation which calculates the largest nitrite concentration.

For tanks with dilute waste that contains sludge the sludge/salt temperature limit is 75°C. The concern is that areas of localized high temperature will develop and result in regions that are uninhibited against pitting. Laboratory tests have shown that as long as the temperature in the lower region of the tank is less than 75°C and the bulk supernate concentration of the aggressive anion is greater than 0.01 M no pitting occurs [20].

Bulk Waste Removal Temperature Limits

Table 6 applies to waste tanks undergoing bulk waste removal, however it can be applied to slurried waste tanks for a defined duration based on an engineering evaluation. The bases for the temperature limits in Table 6 are primarily the same as the bases for Table 5. The only difference between the two tables is the supernate temperature limit when the hydroxide concentration is less than or equal to 1 molar.

Waste removal operations have significant impact on the chemistry and temperature of the supernate. During these operations an inhibited solution, either inhibited water or dilute supernate from another waste tank, is added to the tank undergoing waste removal. This mixture is then agitated with single or multiple

mixing pumps. The supernate chemistry will be impacted as sludge particles are suspended, salts are dissolved, and interstitial liquid from the sludge is mixed with the inhibited solution. The temperature of the supernate will also gradually rise as mechanical energy from the pump is dissipated in the waste tank. The temperature limit for the bulk supernate during slurry pump operation shall be 75°C for supernate with a nitrate concentration less than 1 molar and a hydroxide concentration less than or equal to 1 molar. Laboratory tests showed that if the bulk solution is inhibited with greater than 0.01 molar sodium hydroxide, pitting does not occur below this temperature [20]. The agitation also prevents the occurrence of inhibitor depletion in the thin film above the liquid vapor interface [12]. The supernate in a waste tank is considered to be adequately mixed for the application of these higher temperature limits after at least one slurry pump is operated at or above its normal minimum speed for at least 3 continuous hours. The 3-hour operating time period is based on past operational experience, which indicates that the surface of the liquid is sufficiently agitated within the first 3 hours of pump operation (seen on videotapes of slurry pump operation as well as past experience with Tank 8). Once the pump operations have ceased, the temperature limit for the supernate shall remain at 75°C for no longer than 30 days. However, after 30 days the tank shall be considered to have returned to a "non-slurried" condition. Temperature limits will then be governed by the chemistry of the waste per Tables 3 through 5 of this control program as appropriate [21].

Over the years, the supernate in several waste tanks has been allowed to evaporate, leaving either a saltcake or sludge layer phase. Although there is no supernate above, these phases may contain interstitial liquid that may cause a corrosion concern. Due to the various mechanisms of concentration and depletion that can occur in the interstitial liquid, the composition of the interstitial liquid is difficult to predict. A conservative estimate of the interstitial liquid concentration is that it has the same composition as the supernate that was above the sludge or salt layer prior to the time when the tank became "dry". The actual hydroxide concentration of the interstitial liquid is probably higher due to evaporation of the water from the interstitial liquid. Therefore, the composition results from the most recent sample that was obtained will be utilized to estimate the composition of the interstitial liquid, and hence to determine the temperature limits. Based on these compositions, Table 4 shall be utilized to determine the sludge/salt phase and steel wall temperature limits in dry waste tanks utilizing the salt/sludge levels. If the tanks are re-wetted, an engineering evaluation shall be performed to determine the new temperature limits.

The temperature at the tank exterior surface will be held at least 5°C below the boiling point of the solution. This temperature differential accounts for the maximum temperature drop across the steel wall of < 1°C [22]. This applies only to Types I, II, III and IIIA waste tanks since the Type IV tanks do not have steel wall thermocouples. The waste in Type IV tanks are low heat and therefore do not present a credible potential to boil waste; controls placed by the DSA on the

waste entering Type IV tanks will ensure that this remains true. In addition, other required thermocouples in Type IV waste tanks will be monitored to ensure that waste does not reach its boiling point.

4.1.2 CHEMISTRY

The corrosion inhibitor limits (hydroxide and nitrite) in Table 7 were established to minimize or prevent the corrosion of waste tank walls and cooling coils. The limits are based on experimental data developed at Savannah River Site (SRS). Samples of the waste are taken periodically to determine whether or not the tank is within the corrosion inhibitor limits (see Table 7 and Table 8). The bases for determining the sampling frequency is discussed as well as the requirements for sampling after a waste transfer.

The application of these corrosion inhibitor limits have successfully stabilized and minimized the stress corrosion cracking (SCC) of waste tank carbon steel walls experienced in the early days of SRS and pitting identified in laboratory tests somewhat later. These are the two major corrosion failure modes expected in SRS waste tanks and cooling coils. Since controlled inhibitor addition began in the mid-1970's, there have been no reports of SCC or evidence of it in the stress-relieved Type III and IIIA tanks. The frequency of cooling coil failures has also been minimized (although it is possible that not all cooling coil failures are related to the waste chemistry).

Compliance with these limits may not totally eliminate the potential for cracking of a waste tank. Cracking may occur below the specified temperature as result of concentrations of NO_3^-, NO_2^- and OH^- within the specified limits because of flaws in the metal, stress concentrations, or crevice formations. Cracking may also occur as a result of other corrosion mechanisms involving unknown contaminants that could conceivably be in a waste stream.

The chemistry controls ensure that SCC and pitting of the waste tank walls and cooling coils are mitigated. Corrosion control by addition of chemical inhibitors is the primary means of corrosion mitigation and also the result of continuously diligent and effective research over approximately 40 years. Table 7 summarizes the corrosion inhibitor limits. The primary corrosion inhibitors that are utilized are sodium hydroxide and sodium nitrite, while the primary aggressive species is the nitrate anion. The next sections describe the bases for each of the limits. Temperature limits associated with the various waste chemistries are described in the temperature control section of this document.

Limits 1 to 3 (Table 7):

Carbon steel exposed to alkaline solutions has a low general corrosion rate [26]. However, the presence of the nitrate anion may induce various forms of localized attack (i.e., SCC, pitting, etc.) even in these environments. It has been postulated that cracks are initiated at carbon present in the solid solution or Fe_3C at the grain boundary [27]. Cracks propagate along the grain boundaries of a material as the tensile stress maintains a crevice where the solution remains aggressive towards

the metal. The corrosion rate is influenced by the nitrate reduction kinetics as shown in the equation below [28].

$$NO_3^- + H_2O + 2e^- = NO_2^- + 2\ OH^- \qquad (10)$$

Nitrate is more easily reduced as the solution becomes more acidic. Work at the Naval Research Laboratory has shown that during cracking the solution at the crack tip is approximately pH 3 [29], which is significantly different from the bulk pH. Equation 1 shows that adding hydroxide and/or nitrite anions will reverse the equilibrium of the reduction reaction. Therefore, these anions are useful corrosion inhibitors. Laboratory tests on carbon steel were performed to determine the appropriate combination of inhibitors that would prevent the initiation of new cracks and mitigate the propagation of the current cracks [5, 30 and 31]. Limits 1 to 3 are based on these tests.

As the NO_3^- concentration increases from 1 to 2.75 M, the susceptibility to nitrate SCC increases, and higher concentrations of inhibitors are required [5]. The inhibitor concentration is directly proportional to the nitrate concentration. The presence of 0.3 M OH^- and 1.1 M of $OH^- + NO_2^-$ will inhibit nitrate cracking in wastes containing 2.75 to 5.5 M NO_3^-. From 5.5 to 8.5 M NO_3^-, inhibitors at 0.6 M OH^- and 1.1 M of $OH^- + NO_2^-$ will be sufficient to prevent nitrate SCC.

Limits 4 and 5 (Table 7):

The nitrite and hydroxide minima are specified to minimize the potential for pitting corrosion of the carbon steel tank walls and cooling coils. The inhibitor concentration limits are based on either hydroxide alone or nitrite with a minimum pH level to inhibit pitting [5 and 31-36]. The discontinuity between the 3 and 4 hydroxide limits is due to a change in corrosion mode from SCC to pitting corrosion, and to the conservative approach taken for 4 and 5 to account for the limitations in the available data on which the standard can be based.

Pitting has not been a problem at hydroxide concentrations greater than 1 molar in over 40 years of experience in the tanks. No pitting is observed at 1 molar hydroxide ion for any of the diluted waste solutions tested [15, 35]. A theoretical model indicates that a hydroxide minimum of 1.0 M is sufficient to maintain a minimum pH of 12 in most of the aqueous film [12]. Lower hydroxide concentrations in the film are probably sufficient to protect the steel, especially when nitrite is present. However, there are not sufficient data available to specify a lower hydroxide ion concentration in the bulk solution that will provide adequate protection throughout the film.

The nitrite minimum is based on the concentration required to inhibit pitting of the tank wall or cooling coils in an aqueous film which has reached a steady state pH [35, 15, and 36]. The nitrite requirements include a 50% uncertainty to

account for both the increased requirements when processing worst-case (most corrosive) salt solution, for local variations in waste composition and for differences between actual waste and the laboratory simulants.

The inhibitor levels specified in limits 4 and 5 are based on the aqueous phase reaching steady-state with respect to the absorption of atmospheric carbon dioxide. Alkaline solutions absorb and react with carbon dioxide to produce bicarbonate and carbonate [13]. The steady state pH depends on the initial hydroxide and carbonate levels in the waste and carbon dioxide concentration in the air. The lowest steady-state pH which has been tested is pH = 10.3 [15, 37] and is the minimum specified for all nitrate concentrations below 1 molar. At nitrate concentrations between 0.02 to 1.0 molar, the nitrite concentrations specified by in 4b are sufficient to inhibit corrosion only if the solution pH does not fall below the steady state value of 10.3 [18]. A pH less than 10.3 could put the tank in a regime where adequate protection against pitting is not provided by the nitrite level specified in 4b and 5b [18].

The inhibitor requirements specified in limits 4 and 5 are based on a supernate temperature of 40°C (see background of temperature control). Pitting of carbon steel is worse at temperatures greater than the maximum allowable and greater concentrations of inhibitors would be required for prevention.

In general, the nitrate anion is the aggressive species that causes pitting. However, in very dilute solutions, sulfate or chloride, may become the species that is aggressive [19]. Minimum nitrite concentrations as a function of chloride or sulfate concentration in the supernate are represented by limits 4c and 4d, respectively. A review of limits 4b-d demonstrated that the solution is always inhibited if it contains the maximum value of nitrite calculated from the three equations [19]. For example, if the nitrite concentrations calculated from each equation are 0.5, 0.01, and 0.04 molar for nitrate, chloride and sulfate, respectively, the minimum nitrite required for the supernate would be 0.5 molar.

Therefore, the maximum value obtained from limits 4b, 4c, or 4d shall be utilized to determine the minimum nitrite concentration required to inhibit a dilute solution. Similarly, if the nitrate concentration is less than 0.02 molar, the maximum value obtained from limits 5b if the concentrations of the nitrate, chloride, and sulfate anions are not known, or 5c, 5d or 5e shall be utilized to determine the minimum nitrite concentration required if the concentrations of these constituents are known.

pH limit (Table 7):

This limit ensures that waste from other areas on site, that would rapidly corrode a carbon steel tank or cooling coils if not thoroughly mixed with waste already in the tank, is not routinely added to the waste tanks [38]. Waste that is acidic (pH < 7), could cause severe corrosion damage to parts of the waste tank or cooling coils when it comes in contact before being mixed with alkaline tank contents. The waste acceptance plan has specified pH 9.5 to allow a safety factor above pH 7 to

account for field measurements, which although accurate, may not be precise. The limit does not apply to well water (pH 4 to 5) used for line flushing.

Water Additions

Small volumes of uninhibited water and aqueous solutions are occasionally added to the waste tanks. This program allows the addition of up to 3,000 gallons of water (e.g., flush water, uninhibited water, spring water, well water, and all other forms of water available to the tank farm) to a tank within a rolling 30 day window without any corrective action. This is based on the fact that in the waste tanks, an addition of 3,000 gallons or less of water does not significantly change the inhibitor concentration of that tank's supernate, and within the given time, the inhibitor concentration from the supernate in the tank will diffuse into the water that has been added. In order to ensure this limit is not exceeded, the levels of each inactive tank will be evaluated every 30 days to ensure no unplanned addition of more than 3,000 gallons occurred.

In order for water to be considered inhibited, it must be verified to contain greater than 0.01 M hydroxide and 0.011 M nitrite. All other water additions are considered uninhibited.

Small volumes of uninhibited water and aqueous solutions are occasionally added to the waste tanks. Sources of these additions include rainwater, sump solutions, transfer line flush water, and decontamination solutions. These additions generally do not significantly alter the bulk chemistry of the waste already present in the tank. However, these additions increase the risk of corrosion near the vapor liquid interface. The difference between the densities of water and high level waste results in inadequate mixing of these solutions. Water additions to the tank are likely to separate and form a thin layer on top of the more dense bulk waste. During this time, solute concentrations in this layer are assumed to increase by diffusion only from the bulk waste. Because the water additions are likely to have pHs in the near-neutral range, the potential for corrosion does exist for a period of time before the concentration of inhibitors such as hydroxide and nitrite reach protective values in this added layer. Near-neutral pHs are well below the pH of 10 required to inhibit against pitting corrosion in pure water and the pH of 14 required for solutions containing corrosive anions, such as nitrate, sulfate, or chloride [41]. Water additions will remain corrosive until the required inhibitor concentrations are satisfied by diffusion from the bulk supernate into the addition layer. The inhibitor requirements for this layer were established as either 1M sodium hydroxide or a combination of 0.01M sodium hydroxide and 0.011 M sodium nitrite. These levels of inhibitor have been shown to prevent pitting attack in dilute wastes [41]. Although pit initiation and growth rates for carbon steel in alkaline solutions are not well established, the experience of cooling coil failures during sludge removal operations in the 1960s suggests that pit growth rates may be as high as 0.15 in/month [43]. Some period of time is required to initiate pits, and some pits may repassivate upon the establishment of inhibiting conditions. Diffusion calculations were performed to determine the largest water addition for

which the required inhibitor concentrations are achieved at the top of the layer in a reasonable time frame [77].

If this limit (3,000 gallons) is exceeded or it is anticipated that it will be exceeded, an engineering evaluation for directions or remedial actions shall be performed as soon as practical [41]. The engineering evaluation will consider variables such as the bulk concentration of the waste in the tank, the source of the uninhibited water, and recent additions of uninhibited water to the tank in its recommendation.

Vapor Space Corrosion

General or localized corrosion may occur in the vapor space due to conditions created by relative humidity and the ability of deposited aggressive species on the tank wall to adsorb humidity to form localized aggressive solutions [69]. Several mechanisms were proposed for the deposition of aggressive species on the tank wall within the vapor space to include: 1) salt residue on the steel tank left by evaporation or supernate transfers 2) species may have been deposited on the tank wall by evaporation from the supernate transport as an aerosol followed by condensation on the tank wall. In sufficiently humid conditions, the residue can adsorb atmospheric moisture and dissolve, forming a corrosive electrolyte. Testing indicated that supernate transfers and the consequent residual species on the tank wall is the predominant source of surface chemistry on the tank wall. As such the extent to which the initial solution is inhibited prior to transferring of the solution plays a key role in the corrosion in the vapor space. At the boundary conditions for Chemistry Limits 1 through 3 of the Corrosion Control Program minor and isolated pitting is possible within crevices in the vapor space of the tanks that contain stagnant dilute solution for an extended period of time, specifically when residues are left on the tank wall during supernate transfers.

Table 10 provides supernate chemistry control limits for a tank that is inactive for more than six months [70]. If the tank becomes active during the six month period, the limits in Table 7 remain applicable. These limits apply only to Type III/IIIA tanks. Compliance with these limits will be accomplished by quarterly engineering evaluations to identify any tanks that may not be compliant with the vapor space criteria.

Sampling Frequencies (Table 8 and Table 9)

The sample frequencies in Table 8 are set based on a statistical analysis of the historical corrosion chemistry sample data of the tanks in each category [39] and on an understanding of mechanisms that may change the concentrations of either aggressive or inhibitor species (e.g., hydroxide depletion) [13]. The frequencies in Table 8 may be used for any tank. Tanks that have a sample history of at least 15 samples since the last inter-tank transfer OR since waste was last slurried in the tank, may qualify for further extension of sampling frequency as specified in Table 9.

A 30 day grace period is permitted in the sample frequency specified in Table 8 and Table 9. Sampling results shall be incorporated into the Waste Characterization System (WCS) within 90 days of the date the sample was taken. A 30 day grace period is permitted in the time allowance for sample result incorporation into WCS. A sampling methodology has been documented that describes the types and locations of various samples needed to comply with this and other PDDs [40].

A. Active Tanks

A.1. Evaporator Feed and Drop Tanks

The sample frequency for active evaporator feed and drop tanks shall not exceed 180 days. The relatively frequent transfers into these tanks from several different sources (canyons, DWPF, etc.) may result in significant changes in the corrosion chemistry that need to be trended. Models for hydroxide depletion indicate that for dilute solutions (i.e., nitrate concentration is less than 1 molar) the hydroxide concentration can deplete to the steady state pH level of 9.5-10.3 within 3 to 180 days [13]. Therefore tanks with these composition ranges shall be sampled every 90 days. Models for hydroxide depletion in tanks with concentrated wastes (nitrate greater than 1 molar and hydroxide greater than or equal to 2.35 molar) indicate that at high hydroxide concentrations will take more than 5 years to attain the steady state pH level [13]. Therefore a 180-day sample frequency that will monitor changes in the chemistry due to waste transfers will be sufficient for the more concentrated wastes.

A.2. Fresh Canyon Waste Receiver with Nitrate Concentration Greater Than or Equal to 1 Molar

Fresh canyon waste receivers were separated out as a special case waste receiver. Previous service history show that these tanks, in addition to having relatively lower inhibitor concentrations compared to other waste receivers, also historically have higher temperatures. The higher temperatures result in a greater susceptibility to corrosion degradation mechanisms. Therefore, the sample frequency shall not exceed 365 Days. If the hydroxide concentration is less than 3 M, or the total inhibitor concentration is less than 4 M, the tanks will be sampled on a 180-day frequency.

A.3. Receivers with Nitrate Concentration Less Than 1 Molar

The ratio of the concentration of nitrate to nitrite typically determines whether dilute wastes are within corrosion chemistry limits. The statistical analysis of the historical sample data was utilized to establish the frequencies shown in Table 9. The hydroxide depletion models were reviewed to confirm that these frequencies were adequate. If the hydroxide concentration is less than 2.35 M, depletion models indicate that the steady state pH may be attained within a year [13]. Therefore the 90 and 180-day frequencies are justified. On the other hand, if the hydroxide concentration was greater than 2.35 M, it will take more than 5 years to attain the steady state pH. Therefore, the 365-day frequency is justified.

Dilute wastes may also be inhibited with 1 molar sodium hydroxide per Table 7. Models for hydroxide depletion predict that solutions with high hydroxide concentrations (greater than or equal to 2.35 molar) will take more than 5 years to attain the steady state pH [13]. An exception to these frequencies may occur at very dilute solutions (i.e., nitrate concentrations on the order of 0.01 M). If the chloride or sulfate species becomes the aggressive species rather than the nitrate, the sample frequency will be 90 days. Which species is aggressive can be determined by calculating the minimum nitrite level for each of these species and then determining which species requires the maximum amount of nitrite. The equations for the minimum nitrite calculations are shown in Table 7. The nitrate will be the most aggressive species except in some rare cases of dilute waste.

A.4. Receivers with Nitrate Concentration Greater Than or Equal to 1 Molar

Inhibition of concentrated wastes (nitrate greater than or equal to 1 molar) is achieved with a minimum hydroxide concentration and the combination of hydroxide and nitrite concentrations (see Table 7). Statistical analysis of the sample data was utilized to determine the frequencies based on the risk of being outside the corrosion chemistry controls [39]. The hydroxide depletion models were reviewed to confirm that these frequencies were adequate. If the hydroxide concentration is less than 2.35 M, depletion models suggest that the steady state pH may be attained within a year. Therefore 180 days is an adequate sample frequency. For hydroxide concentrations greater than or equal to 2.35 M, the steady state pH level will not be attained for more than 5 years [13]. Therefore these tanks may be sampled on a 365 day or 730 day basis as determined by Table 9.

A.5. Bulk Waste Removal Tanks

Due to the potential for changing the concentration during slurrying operations, samples shall be taken once every 30 days to verify that the waste remains within corrosion chemistry, unless an engineering evaluation shows that a longer frequency is acceptable to coincide with slurry batch campaigns.

A.6. Salt Processing Tanks

The study of conditions present in tanks containing salt was instrumental in forming the basis for this program. Therefore, all limits listed in this program apply to salt processing tanks as if they were any other active tank. Salt processes are those operations taken to prepare for and perform salt disposition and may include, but are not limited to, salt dissolution and interstitial liquid removal.

During salt dissolution processing, it has been shown that the concentration of inhibitor species (NO_2- and OH-) are depleted and the concentration of the aggressive (NO_{3-}) species is greatly increased [Ref. 71]. It is anticipated that as the salt dissolution process progresses that the tank chemistry will at some point fail to be in strict compliance with the requirements of Table 7, thus introducing the risk of nitrate induced stress corrosion cracking and pitting of the primary tank wall at the liquid air interface.

Water additions will most likely float on top of the salt cake due to differences in the specific gravity of the interstitial liquid and the dissolution water. Dissolution of the salt is controlled by diffusion from salt cake into the layer of dissolution water. This process is relatively slow, and thus the region at the liquid air interface may remain at essentially the same composition as the initial dissolution water for some time.

If inhibited water is utilized the concern for pitting at the liquid air interface is minimized initially. However, if this layer is allowed to remain stagnant the hydroxide inhibitor present at the liquid air interface will begin to deplete due to a reaction with carbon dioxide [Ref. 13].

A corrosion control plan [Ref. 71] was prepared to mitigate these risks and to allow the salt dissolution to move forward without the addition of inhibitors. The controls include lowering temperature limits and stagnant liquid air interface time limits with specific action items to protect both the tank where salt dissolution is performed and the tank that receives and stores the dissolved salt solution.

B. Inactive Tanks

B.1. Receivers with Nitrate Concentration Less Than 1 Molar

Inactive tanks have not received any transfers for over 365 days. Thus any change in the supernate chemistry would be due to hydroxide depletion. The ratio of the concentration of nitrate to nitrite typically determines whether dilute wastes are within corrosion chemistry limits. The statistical analysis of the historical sample data was utilized to establish the frequencies shown in Table 8 [39]. The hydroxide depletion models were reviewed to confirm that these frequencies were adequate. If the hydroxide concentration is less than 2.35 M, depletion models indicate that the steady state pH may be attained within a year [13]. Given that there are no transfers into the tank within a year, the 180 and 365-day frequencies are justified. On the other hand, if the hydroxide concentration was greater than 2.35 M, it will take more than 5 years to attain the steady state pH. Therefore, the 730-day frequency is justified. Dilute wastes may also be inhibited with 1 molar sodium hydroxide per Table 7. Models for hydroxide depletion predict that solutions with high hydroxide concentrations (greater than or equal to 2.35 molar) will take more than 5 years to attain the steady state pH [13]. An exception to these frequencies may occur at very dilute solutions (i.e., nitrate concentrations on the order of 0.01 M). If the chloride or sulfate species becomes the aggressive species rather than the nitrate, the sample frequency will be 90 days. Which species is aggressive can be determined by calculating the minimum nitrite level for each of these species and then determining which species requires the maximum amount of nitrite. The equations for the minimum nitrite calculations are shown in Table 7. The nitrate will be the most aggressive species except in some rare cases of dilute waste.

B.2. Receivers with Nitrate Concentration Greater Than or Equal to 1 Molar

Inactive tanks have not received any transfers for over 365 days. Thus any change in the supernate chemistry would be due to hydroxide depletion. Inhibition of concentrated wastes (nitrate greater than or equal to 1 molar) is achieved with a minimum hydroxide concentration and the combination of hydroxide and nitrite concentrations (see Table 7).

Statistical analysis of the sample data was utilized to determine the frequencies based on the risk of being outside the corrosion chemistry controls [39]. The hydroxide depletion models were reviewed to confirm that these frequencies were adequate. If the hydroxide concentration is less than 2.35 M, depletion models suggest that the steady state pH may be attained within a year. Given that there have not been any transfers into this tank for over a year, 365 Days is an adequate sample frequency. For hydroxide concentrations greater than or equal to 2.35 M the steady state pH level will not be attained for over 5 years [13]. Therefore these tanks may be sampled on a 730 or 1460-day basis depending on the results of the statistical analysis and/or the guidelines established in Table 8.

C. Exceptions to the Sample Frequency Rules

If a waste tank has been sampled 15 times since the last inter-tank transfer or since waste was slurried in the tank AND the statistical capability of the tank to meet minimum corrosion inhibitor limits (Sigma Level) can be established [39], the sample frequency for that tank may be determined using Table 9. If the frequency is extended using this provision, the extension will be documented in the ERD [42].

Evaporators

In order to prevent corrosion of the evaporator tube bundles, it is required that they either be submerged in waste or in inhibited water (unless the tube bundle is deemed Out of Service (OOS)). The basis document for the corrosion control program recommends that the tube bundle not be left uncovered for more than 30 days [54]. During the period of time when the evaporator is not operating, the pot shall have a pH greater than 12, as calculated by the following formula. During normal operation, the tube bundles are covered with waste that is sufficiently inhibited to prevent corrosion.

The amount of inhibitor needed to raise the pH in the evaporator pot to above 12 is very minimal. The 2F and 2H evaporators require approximately 11 gallons of 50 wt% caustic to raise the pH to 13; in the 3H, it takes approximately 53 gallons. The following equation yields the volume of 50 wt% caustic that is necessary to be added to increase the pH of the pot contents to 13.

$$(0.1 * (\text{gallons in pot})) / 19 = x \text{ gallons caustic} \qquad (11)$$

This equation determines the gallons of 50 wt% caustic that needs to be added by taking the product of the desired concentration of 0.1 M (pH 13) and the gallons in the pot and dividing this product by the concentration of the 50 wt% caustic (19 M).

Credit may be given for the waste left in the evaporator pot, if it is sufficient to bring the pH of the pot over the minimum of 12, and the lance is operating when the water addition to the waste is made. To calculate whether the waste is sufficient to inhibit, use the free hydroxide concentration of the evaporator feed tank, multiply it by the expected volume of the waste left in the pot; then, divide by the total volume of the liquid in the pot. This number is the actual free hydroxide concentration in the pot. If this value is above 0.01 M, the waste left in the cone is sufficient to inhibit the pot. If not, the addition of caustic as described above must be completed within 30 days.

The intent of this program is to ensure that the tube bundle in the evaporator pot is submerged in an inhibited solution very quickly after going into an extended shutdown. This minimizes the chances for the initiation of corrosion on the tube bundle. This basis document was written specifically for the 2H and 2F evaporators, but a later evaluation [55] confirmed that this control can be extended to the 3H evaporator as well.

The evaporator tube bundle must also be protected against failure due to MIC. However, the high temperatures of the steam in the tube bundle kill all the microbiological entities that could cause this form of corrosion, so no further controls need to be placed on the system.

Prevention of Microbiologically Induced Corrosion (MIC)

MIC has not been observed in any of the tank farm systems; however some conditions at SRS do cause concern over the possibility of MIC occurring. The conditions that cause MIC concerns are stagnant water, low pH (pH<10.5), temperatures less than 100°F, presence of organic matter, and the absence of a biocide [56]. On occasion, uninhibited water is used in the tank farm, primarily for flushing transfer lines after a transfer, which could produce conditions that would encourage MIC.

In order to prevent conditions that would be favorable to MIC, transfer lines shall be vented and drained after each transfer. If there are known “low” points in the transfer line (as identified in the Structural Integrity (SI) Program), and that line needs to be flushed, that line must be flushed with inhibited water (pH>12) unless another waste transfer is planned within the next 5 days. A five-day maximum on the time that uninhibited water can remain stagnant in a transfer line has a technical basis combined with engineering prudence [56].

Chromate Cooling Water Lines

The cooling coils in each of the waste tanks are protected against corrosion from the exterior by the inhibitor and temperature requirements required for each of the waste tanks in this program. The interior of the cooling coils is protected against corrosion by the chromate that is in the cooling water. Periodic testing (at least every 90 days) of the chromate cooling water for the appropriate levels of chromate (greater than 450 ppm) coupled with a required flush of all isolated chromate cooling coils every 90 days will ensure that the cooling coils are

sufficiently protected against internal corrosion. A chromate concentration of 450 ppm must be verified every 90 days, because in a period longer than 90 days it is possible for the chromate concentration to decay down to approximately 200 ppm, which is the minimum level, needed to prevent corrosion.

A decision to not protect a certain cooling coil by the Facility Manager shall exempt that cooling coil from the requirements of this program, provided the coil is out of service.

The supports for the cooling coils that are in a waste phase are also protected by the temperature and chemistry controls on the waste in each tank. The vapor space corrosion section of this program is applicable to the supports for the cooling coils that are in the vapor space of the tank.

During the closure process, there is a potential risk of through-wall pitting of the cooling coils [1].

4.1.3 HUMIDITY

Annulus ventilation is required to prevent corrosion of the external tank wall, the secondary pan, and the secondary wall of double wall tanks due to the potential formation of condensate on the walls. Preheating the annulus air is required if the tank wall is less than 40°C.

Based on a review of SRS meteorological data, obtained from the onsite weather services of the Atmospheric Technology Group, including the dew point temperatures in the tank farm over the time period from 2000 to 2002, it was concluded that if the lowest tank steel-wall temperature is above 40°C, steam is not required to protect the annulus. This review discovered that typically, the dew point does not go above 80°F. No recorded dew point over the past 730 days exceeded 100°F [Ref. 74]. Therefore, if the tank's lowest steel wall temperature is above 40°C (104°F) (excluding tanks in Acidic and Non-Acidic Chemical Cleaning Mode and Closure Mode), no condensation should occur in the annulus. However, if liquid is detected (from rainwater, etc.) in the annulus, steam shall be, if the steam supply is functional, supplied to the annulus until it is dried, regardless of the temperature of the tank wall.

For tanks with a low heat generation rate, continuous operation of the annulus ventilation system with steam on prevents condensation from forming on the exterior of the primary tank wall and the secondary pan or wall of double-walled tanks as well as evaporating any standing liquid from the annulus pan. Heat, provided by the steam, is utilized in the system to raise the temperature of the air, causing the relative humidity to decrease, and thus minimizes the potential for condensation. The presence of water in the annulus may cause significant corrosion of the tank walls. Occasionally the annulus ventilation system needs to be shut down for repairs to supporting systems such as low pressure steam. This program places limits on the time which the annulus ventilation system may be shutdown. Provisions have also been made to operate the fans if steam is not available. During continuous operation in this mode, there is a risk that there will

be periods of time when condensation and rainwater will accumulate and therefore over time the integrity of the tank will degrade due to corrosion. Long term operation in this mode is not recommended. The only limitation of utilizing the annulus fans with no steam is that the tank wall temperature must be greater than the nil-ductility transition temperature (NDTT) (see [3]). For tanks with a high heat generation rate, continuous operation of the annulus ventilation system (without steam on) removes excess heat from the tank. Due to the high temperatures near the bottom of these tanks, water typically would evaporate rapidly and be removed due to the circulation of the air.

The purpose of this requirement is to prevent corrosion degradation of the exterior primary wall, the secondary pan, and the secondary wall of the double wall tanks. The degradation may result in an inadvertent release of radioactive material to the surrounding environment. Operation of the annulus ventilation in high heat tanks lowers the temperature of the primary steel and thus minimizes the potential for corrosion degradation of the steel or thermal degradation of the concrete. The annulus conductivity probe, a safety-significant instrument detects standing liquid in the annulus. Operation of the annulus air with steam will evaporate the water and prevent corrosion of tank steel. After 30 to 40 years of operation with steam, insignificant degradation of the tank walls has occurred. Operation of the ventilation fans with no steam will evaporate some of the moisture and reduce the potential for production of nitric acid and is therefore better than not operating the fans at all. However, there is a risk that there will be periods of the year when condensation and rainwater will accumulate in the annulus, and therefore over time the integrity of the tank will degrade due to corrosion.

For tanks that have a low heat generation rate, continuous operation of the annulus ventilation system in the past has prevented excessive general corrosion of the primary or secondary tank walls. The intent of this program is to prevent shut-down of the tank annulus ventilation systems for extended time periods. The annulus ventilation system, operated with steam, provides warm air to the annulus that minimizes the accumulation of moisture. Moisture in the annulus causes four concerns for the annulus integrity, (i) for cracked tanks, the moisture will dissolve salt deposits covering the leaksites and allows for intrusion of waste into the tank annulus [48], (ii) for all tanks, radiolysis of the air produces NO_2 gas which reacts with the moisture to produce the highly corrosive nitric acid [45], (iii) for all tanks, microbiologically induced corrosion (MIC) may initiate [46], and (iv) for all tanks, corrosion products may hide defects and therefore prevent the detection of changes in the tank wall surface by tank inspection.

Several Type I tanks and all of the Type II tanks have leaked waste through cracks into the annulus. The warm air circulating through the annulus evaporated the water from the waste and formed salt deposits that plugged the cracks and prevented further leakage. Inspections have shown that when the annulus ventilation is turned off, these deposits begin to dissolve and leakage of waste into the annulus resumes [48]. The dissolution of the salt deposits is likely due to the formation of condensation on the tank walls as the air cools. Although the waste

should be inhibited when it enters the annulus, dilution due to rainwater intrusion or reaction with carbon dioxide may change the chemistry of the leaked waste significantly from that of the waste inside the tank. Thus a new corrosive condition may be created.

Moisture by itself will cause general corrosion. Accelerated general corrosion may occur due to air radiolysis. This mechanism is initiated by gamma rays that irradiate the annulus air to produce NO_2 gas [47]. A nitric acid solution will form wherever air containing NO_2 is in contact with moisture. The reaction producing the nitric acid is:

$$2\ NO_2(g) + H_2O = HNO_2 + H^+ + NO_3^- \qquad (12)$$

If it is assumed that the dose rate is 1000 R/hr (a representative value for the annulus air [48]), and the volume of air in the annulus is approximately 23,000 ft^3, the production of NO_2 gas is 1.9 x 10^{-8} atm/hr. Assuming that equilibrium is instantaneously established, the pH of the standing water may reach 2.9 within 1 hour. At this pH, carbon steel corrodes at a rate of approximately 40-50 mils per year [49]. If these conditions were allowed to persist significant wall thinning may occur. This mechanism was observed to occur in the reactor process room at SRS [50]. Inspections of the annular space to date have not revealed indications of excessive general corrosion [51] even with occasional steam and blower outages. There are several possible explanations for the lack of observed general corrosion. First, the rate at which the nitric acid production reaction occurs in cold dilute solutions may be slow [52], and therefore, the reaction may not attain equilibrium rapidly. Second, the contents of the tank may have contributed sufficient heat to maintain the temperature of the annulus air above the ambient temperature. Condensate would not form under these conditions. Third, the above calculations assume that the air in the annulus is stagnant. A small air flow in the annulus may dilute the NO_2 concentration sufficiently. Fourth, in tanks that have salt deposits, the condensate or standing water may contain other dissolved salts. The presence of these dissolved salts would likely decrease the absorption of the NO_2 gas into the water and the formation of nitric acid.

A final consideration is the potential for MIC. MIC was observed in the annulus pan during construction of the Type III tanks [46]. Wet, stagnant conditions were ideal for initiating pits beneath the microbes. The solution to the problem was to run warm annulus air to remove the moisture that sustains the microbes and the corrosion reaction. Maintaining warm air in the annulus minimizes the potential that this mechanism will initiate new pits or reinitiate pits that are present.

Given that the Type I and II tanks are older and have experienced more degradation, the allowable time period for a ventilation outage is 30 days. Also should defects form (i.e., pits or cracks), the structure will be more susceptible to brittle fracture due to the high nil-ductility transition temperature of the steel used for these tanks. Moisture build-up in the Type III and IIIA tanks is also undesirable. However, the lack of any known leaksites and the superior materials

and fabrication procedures used for these tanks allows for a longer allowable outage period.

There are situations where steam is not available to heat the ambient air prior to entering the waste tanks. If steam is not available, the annulus fans may be turned on in order to evaporate moisture as long as the tank walls remain above the low operating temperature limit on the roundsheets. The minimum temperature limit on the roundsheets ensures that the tank wall temperature remains above the minimum NDTT value (excluding tanks in Acidic and Non-Acidic Chemical Cleaning Mode and Closure Mode) [3] by a sufficient margin. The temperature limit minimizes the potential for brittle fracture of the tank walls. Portable fans may also be utilized in this situation. Due to the convection of the air, some undetermined amount of moisture (which depends on the temperature and relative humidity of the ambient air and the heat generated by the tank) will be evaporated. Additionally the air flow will reduce the concentration of NO_2 in the annulus that was produced by radiolysis. Therefore, although corrosion would occur due to moisture, it would not be accelerated by nitric acid. However, there will be time periods during the year when condensation will accumulate in the annulus. This mode of operation is not ideal; however, it may be utilized on an interim basis.

In addition to moisture due to condensation, rainwater leaks into the annulus through risers and other penetrations such as transfer lines. Conductivity probes are set near the floor of the waste tank annulus to detect the presence of liquids. The probes should be located as near as practical to the annulus floor to minimize the accumulation of liquid. In some situations, debris or waste prevents the probe from being placed directly on the annulus floor. Two benefits are realized by minimizing the accumulation of liquid: 1) the potential for deflagration or the accumulation of flammable gases is reduced and 2) long-term corrosion degradation of the pan, annulus floor, annulus wall or primary tank is mitigated or prevented. The first benefit reduces the risk of releasing a radioactive dose to the public. Given that this is the more immediate concern of the two, the level that the probe is set above the annulus floor (in the presence of debris or accumulated waste) will be based on this consideration. The second benefit maintains the structural integrity of safety class structures over an extended period of time. The maximum probe height settings are described in the Technical Safety Requirements (TSRs).

Circulation of warm air will evaporate rainwater and prevent the possibility of corrosion. For example, a test was performed that showed that operating the annulus ventilation at 2200 CFM, with an inlet temperature of 96°C, would evaporate approximately 10 gallons of liquid per hour [53]. In the event that steam is not available to heat the ambient air, the ventilation fans or portable ventilation fans shall be operated to evaporate the water. Although the drying capacity of the air is significantly decreased during periods of time when the humidity is above 50%, blowing air across the accumulated water will evaporate

water as long as the ambient air is below 100% relative humidity. The tank steel wall temperature shall be monitored also to ensure that it does not go below the minimum value i.e., the NDTT (excluding tanks in Acidic and Non-Acidic Chemical Cleaning Mode and Closure Mode).

For tanks with a high heat generation rate, circulation of air that has not been pre-heated with steam has been utilized to cool the waste tank steel. Cooling the waste tank in this manner minimizes the potential for corrosion degradation of the steel (see Temperature Control) or thermal degradation of the concrete (see Structural Integrity Program). Typically, the heat from the high heat tanks in combination with air convection will evaporate water from the annulus in a relatively short period of time.

4.2 *Cleaning Activity Life Cycle*

Tanks in the Cleaning Activities life cycle are undergoing vigorous cleaning activities. These activities include bulk sludge removal, bulk salt dissolution, and chemical cleaning (applicable to Type I/II waste storage tanks, excluding Tank 1). During the Cleaning Activities Life Cycle, the program allows for the suspension of corrosion inhibitor concentration requirements, sampling frequencies (shown in Table 8), and maintaining annulus ventilation requirements for up to 1460 days for waste removal activities, which accounts for a bounding case of the tank being exposed to oxalic for 365 days (Feeding 4 to 8 wt% oxalic acid at 60 to 75°C with no mixing for ≤ 30 days and the remainder of time at ≤ 4 wt% oxalic acid at 60°C) for chemical cleaning activities. A more realistic case for chemical cleaning activities is approximately 6 months. Since the life cycle is short, the corrosion controls imposed are greatly diminished, but are adequate to ensure that sufficient tank integrity remains to complete the closure process.

Applicable DSA designations include Gas Release, Operation, Acidic Chemical Cleaning, and Non-Acidic Chemical Cleaning Modes. Once the tank is declared clean and no further aggressive cleaning is required, the tank will transition into the Final Stabilization Preparation Life Cycle Stage. This declaration stops the Cleaning Activities Life Cycle Stage time clock (1460 days).

4.2.1 TEMPERATURE

Maximum temperature limits are applicable for each waste phase and the tank steel wall as established for the Normal Operations Life Cycle Stage. More restrictive temperature limits are applied for tanks that are undergoing acidic chemical cleaning during acid addition and mixing evolutions.

In assessing the waste storage tanks, going through the cleaning activities life cycle stage, temperature was an important variable for estimation of the expected corrosion rates during waste removal activities [1]. Bounding temperatures for each of the activities were assumed for the analysis. The maximum temperature experienced during bulk sludge removal due to mechanical heat generated by mixing devices is expected to be 60°C. The maximum temperature for salt

dissolution is expected to be 50°C. The maximum temperature in tanks storing salt cake is approximately 50 ºC [23]. Additionally, salt dissolution is an endothermic process, which lowers the temperature of the waste below 50 ºC [24]. The target temperature for heel removal with oxalic acid is 50 °C [1]. However, the reaction between the oxalic acid and the sludge is exothermic and the mixer pumps will also add mechanical heat to the system [1]. Therefore a reasonable maximum temperature for the oxalic acid chemical cleaning process will be 60 °C.

These operations are very low-volume operations or involve mixing pumps at high volumes. The highest temperatures are likely during the slurrying process, when the pumps are adding heat to the tank and may challenge temperature limits. Consequently, temperature shall be monitored every shift when the mixing pumps are operating. After the slurrying process, the mixing devices are turned off and most of the heat-generating sludge-slurry mixture is transferred out of the tank. Therefore, it is expected that the temperatures will not challenge the limits during low-volume phase of the process.

During Chemical Cleaning of Type I/II waste tanks, the concrete vault and, in the case of the Type I tanks, the concrete columns are credited for structural integrity controls for normal operation and natural phenomena events. The steel tank wall is not credited and therefore embrittlement of the primary tank wall is not an issue. Type I/II Chemical Cleaning Waste Tanks are exempt from NDTT requirements [62].

4.2.2 CHEMISTRY

The engineering assessment of waste tanks in the Cleaning Activities Life Cycle assumed that well water, which is conservatively bounding for inhibited water and supernate in terms of corrosion inhibitors, would be utilized for bulk waste removal operations, and that up to nominally 8 wt. % oxalic acid would be the method for chemical cleaning[1]. The structural integrity of waste tanks going through the Cleaning Activities Life Cycle was shown to remain acceptable through the entire proposed cleaning process assuming a total of 1460 days of process activities which includes the waste tank being exposed to OA for 365 days (Feeding 4 to 8 wt% oxalic acid at 60 to 75°C with no mixing for ≤ 30 days and the remainder of time at ≤ 4 wt% oxalic acid at 60°C) for chemical cleaning activities [1]. The presence of corrosion inhibitors was not considered in the analysis. Therefore, if the tank has been declared a waste tank in the Cleaning Activities Life Cycle no minimum hydroxide or nitrite concentrations are required (Table 7).

Acidic Chemical Cleaning Impacts to Treatment Tanks

The goal of acidic chemical cleaning is to break-up and dissolve the residual sludge solids heel (< 10,000 gallons) that remains in the tank so that final closure activities (i.e., grouting of the tank) may proceed. The baseline process for chemical cleaning utilizes oxalic acid (OA) and the tank that is being cleaned is

referred to as the treatment tank. OA at a maximum concentration up to 8 wt% is added to a treatment tank followed by water to dilute the solution to ≤ 4 wt%. The evolution of adding acid to the treatment tank, diluting with water, operating the mixing pumps, and transferring the solution to a receipt tank will be completed in a short period.

Corrosion of carbon steel waste tanks and dissolution of iron oxides in oxalic acid can result in a build-up of ferrous ions and ferric oxalate complexes in an acidic environment. During the chemical cleaning process, the concentration of ferric species increases due to dissolution of iron oxides such as hematite, magnetite, and iron oxide corrosion products such as goethite or lepidocrocite that reside in the sludge solids and in a layer of mill scale or corrosion product on the tank wall. Ferric ions may also evolve as ferrous species which react with oxygen present in the solution. Ferric oxalate complexes are relatively stable and remain soluble in oxalic acid; however ferrous ions could also result in the deposition of ferrous oxalate at the metal surface. This ferrous oxalate can serve to passivate the surface and mitigate corrosion.

Laboratory test were conducted to [References 25 and 64] to correlate the impact of OA sludge dissolution of Purex and HM sludge on waste tank corrosion and the propensity for corrosion induced hydrogen generation. Tests were performed with a 20:1 volume ratio of OA to sludge for acid concentrations of 8 wt%, 4 wt%, and 2.5 wt% with and without agitation. The tests also varied temperatures between 25-75°C. From Reference 25, corrosion rates were observed during a simulated waste test of 8 wt% OA in contact with Purex sludge (Tank 5 simulated sludge). Testing used vertical coupons to simulate the primary tank wall. Corrosion rates increased with an increase in temperature and agitation. Localized forms of corrosion were not an issue. Laboratory tests were also performed on an HM simulant at four conditions representative of the anticipated maximum operating conditions that may occur during the acidic chemical cleaning process [64]. The tests were performed with a 20:1 volume ratio of OA and sludge in contact with 8 wt%, 4 wt%, and 2.5% wt% acid concentration with and without agitation at 60 and 75°C. Test included a series of carbon steel coupon immersions and in-situ electrochemical tests conducted concurrently. Polished ASTM A285 grade C carbon steel coupons were immersed in sludge simulant/OA mixtures and removed from the test solution according to a four week planned interval test program. The program allowed for the assessment of changes in solution corrosivity and/or metal corrodibility over an extended period of time. The coupons were analyzed by gravimetric techniques (i.e., weight loss) to determine time-averaged general corrosion rates and pit penetration depths for each environmental condition.

Test results from coupon immersion in 2.5 and 4 wt.% OA at 60 ºC with mixing indicated that general corrosion was the dominant corrosion mechanism at these conditions. Time averaged general corrosion rates decreased over the test interval. The solution corrosivity decreased over the four week test and general corrosion rates indicated that the metal corrodibility increased. This indicates that the

ferrous oxalate became less effective at passivating the surface over the duration of the test.

At 8 wt% OA and 60 ºC with mixing, tests results indicate that both general corrosion and pitting occur. The time averaged general corrosion rates increased with each time interval for the test at 60 ºC with mixing. General corrosion rate and maximum penetration shows that the solution corrosivity increased over the four week test. The general corrosion rate indicated that the metal corrodibility decreased over the four week test. This result indicates that the ferrous oxalate became more effective at passivating the surface over the duration of the test. Maximum penetration on the other hand indicated that the metal corrodibility increased over the duration of the test. This indicated that the passive film was less protective against metal penetration.

At 8 wt% OA and 75 ºC stagnant tests results indicate that both general corrosion and pitting occur. The time averaged general corrosion rates decreased with each time interval. This result indicated that the solution had become less aggressive and/or the ferrous oxalate film had become more protective as the test progressed. Maximum and average pit depths also increased for each of the time intervals through the 3 week test. Both general corrosion rate and maximum penetration shows that the solution corrosivity decreased over the four week test. General corrosion rate indicated that the metal corrodibility also decreased over the four week test. This result indicates that the ferrous oxalate became more effective at passivating the surface and that the ferric oxalate complex has depleted over the duration of the test.

The corrosion rate is directly proportional to the hydrogen generation rate at potentials where hydrogen evolution is the dominant cathodic reaction. Linear polarization resistance was utilized to determine instantaneous corrosion rates (ICR) during this period. The maximum observed corrosion rates during the period where hydrogen was both thermodynamically and kinetically favored was converted to hydrogen generation rates. The hydrogen generation rate determined in Reference 64 will be utilized as the safety analysis value (i.e., 4.3E-05 ft3/min-ft2) imposed by the Flammability Control Program Description Document.

Acidic Chemical Cleaning Impact to Waste Tank Transfer Facility

The Waste Tank Chemical Cleaning Program imposes controls to maintain transfers from Acidic Chemical Cleaning Tank at 60 ºC or less at an OA concentration of 4 wt% or less [62]. Based on recent testing [64] at these conditions the highest general corrosion rate is 45 mpy.

Reference 67, which addresses the transfer times for spent chemical cleaning solution in the transfer facility from Tank 12 to HDB2 and allowable stresses based on wall thinning was revised to reflect recent DSA controls as a result of testing in Reference 64. The maximum time allowed for spent chemical cleaning solution in the transfer facility for existing 3” Sch. 40 carbon steel transfer line is 617 days without exceeding ASME B31.3 code allowable stresses.

Acidic Chemical Cleaning Corrosion Impact to Receipt Tank(s)

Applicable active receipt tank will be selected to receive dissolved sludge from the chemical cleaning process where it will be utilized to neutralize spent oxalic acid. Laboratory tests have demonstrated that if the waste in the chemical cleaning receipt tank is not agitated, the less dense oxalic acid solution will accumulate at the surface [25 and 68]. To diminish potential corrosion, mixing must be accomplished quickly to neutralize the less-dense-acidic oxalic layer. The same tests demonstrated that short periods of moderate energy mixing were sufficient to blend the liquid layers and raise the pH of the solution near the surface.

4.2.3 HUMIDITY

Annulus ventilation is not required for waste tanks in the Cleaning Activities Life Cycle stages because significant corrosion degradation due to intermittent condensation on the tank wall is not anticipated during the short-term closure process [1]. **However, annulus ventilation is a credited control imposed by the Flammability Control Program.**

4.3 *Final Stabilization Life Cycle*

Active corrosion protection for waste storage tanks in the Final Stabilization Preparation stage is not required and the tank is exempt from the Corrosion Control Program Description Documents controls. Final Stabilization Preparation Life Cycle applies to waste tanks in Closure Mode. The Closure Mode tank is physically and electrically isolated from support services (e.g. thermocouples, riser access, annulus ventilation, etc.) in preparation for final stabilization with grout. Final grouting is authorized via a stringent review and approval process. This approval process can result in a significant delay from the time the tank enters the Final Stabilization Preparation life cycle stage to the time the tank is finally grouted. Administrative controls require the tank be stabilized within 10 years and any return to service shall be authorized only by engineering evaluation(s) ensuring the integrity of the tank is sufficient to meet the intended return to service DSA mode designation.

A fracture assessment [63] demonstrated that the risk of brittle fracture of Type I and II tanks in Closure Mode is unlikely.

5.0 Program Controls

5.1 *Normal Operations*

5.1.1 TEMPERATURE CONTROLS

Thermocouples

A functional thermocouple is required in each waste phase (supernate, sludge, and salt) for all tanks except for the supernate phase in the evaporator drop tanks. Drop tanks do not require a functional supernate thermocouple while the evaporator is operating. However, a functioning supernate thermocouple is required within 7 days of cessation of evaporator operations.

A functional thermocouple is required to monitor the steel wall temperature on all Type I, II, III, and IIIA waste tanks. Tanks 1-15 and 29-34 also require a steel wall thermocouple within 3 feet of the bottom knuckle weld.

An instrument loop calibration must be completed annually for the thermocouples in each waste tank. This is to ensure that the thermocouples are functioning properly. In addition, the steel wall thermocouples for Tank 1-15 and 29-34 must be checked bi-annually by visual inspection (i.e., cameras) to ensure they are still attached to the tank wall within 3 feet of the bottom knuckle weld.

If a transfer into or out of a tank results in a waste phase containing no functional TC, the TC in the adjacent phase may be used if it is determined to be representative (similar to or hotter than). The only exception is for evaporator drop tanks during evaporator operations. During this time, the supernate temperature limits do not apply to these tanks. [Basis: The evaporator drop tanks are excluded from supernate temperature requirements during evaporator operation due to the fact that the liquid/air interface during this time is moving (not stagnant), the evaporator is actually concentrating caustic in the drop tank, the liquid that is dropping is not boiling, and past experience shows that evaporator bottoms have been used to actually stop corrosion (evaporator bottoms were transferred to Tank 11 in the late 1960s in order to mitigate cooling coil failures [43]). However, the temperature limits do apply when the tank is no longer functioning as a drop tank, but rather as a storage tank (7 days following the termination of evaporator operation).

Roundsheets, ticklers, or PassPort will be used to prompt and record the temperature readings. Loop calibrations will be prompted by PassPort. Loop calibrations for tanks in Acidic Chemical Cleaning mode will be prompted through the Surveillance Tracking Database.

Temperature Limits

Minimum Temperature Limits

Maintaining the tank temperature above the nil ductility transition temperature (NDTT) for carbon steel tanks during Normal Operations and Cleaning Activities Life Cycle (excluding tanks in Acidic and Non-Acidic Chemical Cleaning Mode) are intended to minimize the probability of failure due to brittle fracture. Table 2 provides the wall temperature limits necessary to reduce the risk of brittle fracture to acceptable levels. No wall temperature limit is required for Tank 38 through Tank 51 to maintain the NDTT due to the unlikely probability of achieving a tank wall temperature of -12 ºC [1].

Table 2- Minimum Temperature Limits for Nuclear Waste Tanks

Tanks	Tank Type	Wall Temperature Limits (º C) for Normal Operation and Cleaning Activities Life Cycle[1]	Temperature Limits for Final Stabilization Preparation Life Cycle
1 -12	Type I	21	No Monitoring Required
13-15	Type II	21	No Monitoring Required
21-24	Type IV	N/A	N/A
29-34	Type III	21	No Monitoring Required
25-28, 35-37	Type IIIA	15	No Monitoring Required
38-51	Type IIIA	No Monitoring Required	No Monitoring Required

Note: (1) Minimum wall temperature limits are not applicable to Type I/II Chemical Cleaning Waste Tanks

Maximum Temperature Limits

Maximum temperature limits for the waste and tank wall are specified to minimize the risk of corrosion. The following tables provide temperature limits dependent upon the concentration of nitrate and inhibitors.

Table 3. Maximum Temperature Limits For Supernate (T_{sup}) With Nitrate Concentrations Greater Than Or Equal To 1 Molar (M) (See Note 1 and 3)

Nitrate (M)	**R<2**	**R≥2**
$1.0 \leq [NO_3^-] \leq 2.75$	70°C	105°C
$2.75 < [NO_3^-] \leq 5.5$	105°C	112°C
$5.5 < [NO_3^-] \leq 8.5$	70°C	See Note 2
Applicable for [OH] ≥ 8 M		
Nitrite (M)	**T≤10**	
$[NO_2^-] \geq 0.3$	115ºC	

T_{sup} = supernate temperature $R = ([NO_2^-] + [OH^-]) / [NO_3^-]$

$T = [OH] / ([NO_{3-}] + [NO_{2-}])$

Note 1: For the most recent concentrations of nitrate, nitrite, and hydroxide in each tank, review the WCS.

Note 2: Due to the liquid solubility limitations, it is not possible to have these supernate compositions.

Note 3: Lower temperature limit of 50 ºC applies during Salt Dissolution Processing

Table 4. Maximum Temperature Limits For The Sludge/Salt and Steel Wall (T_{ss}, T_w) With Nitrate Concentrations Greater Than Or Equal To 1 Molar (M) (See Note 1).

Supernate Concentration	R < 2		R ≥ 2	
Nitrate (M)	Liquid Level < 120 inches	Liquid Level ≥ 120 inches	Liquid Level < 120 inches	Liquid Level ≥ 120 inches
$1.0 \leq [NO_3^-] \leq 2.75$	T_{ss} = 105°C T_w = 100°C	T_{ss} = 115°C T_w = 110°C	T_{ss} = 105°C T_w = 100°C	T_{ss} = 115°C T_w = 110°C
$2.75 < [NO_3^-] \leq 5.5$	T_{ss} = 105°C T_w = 100°C	T_{ss} = 115°C T_w = 110°C	T_{ss} = 112°C T_w = 107°C	T_{ss} = 122°C T_w = 117°C
$5.5 < [NO_3^-] \leq 8.5$	T_{ss} = 105°C T_w = 100°C	T_{ss} = 115°C T_w = 110°C	See Note 2	See Note 2

T_w = Waste tank steel wall temperature T_{ss} = Temperature of the salt or sludge phase

Note 1: For the most recent concentrations of nitrate, nitrite, and hydroxide in each tank, review the WCS.

Note 2: Due to liquid solubility limitations it is not possible to have these supernate compositions.

Note 3: Applicable to sludge/salt temperatures and steel wall for “Dry” tanks.

Table 5. Maximum Temperature Limits For Waste Tanks With Nitrate Concentrations Less Than 1 Molar (M) (See Note 1).

Supernate Concentration	T_{sup}		T_{ss}, T_w	
Hydroxide (M)	$[NO_3^-] \leq 0.02$ M	$0.02 \text{ M} < [NO_3^-] < 1$ M	$[NO_3^-] \leq 0.02$ M	$0.02 \text{ M} < [NO_3^-] < 1$ M
$0.01<[OH^-] \leq 1$	40°C	40°C	$T_{ss} = 75°C$ $T_w = 70°C$	$T_{ss} = 75°C$ $T_w = 70°C$
$1 < [OH^-] \leq 8$	60°C	100°C	$T_{ss} = 60°C$ $T_w = 55°C$	$T_{ss} = 100°C$ $T_w = 95°C$
$[OH^-] > 8$	60°C	60°C	$T_{ss} = 60°C$ $T_w = 55°C$	$T_{ss} = 60°C$ $T_w = 55°C$

Note 1: For the most recent concentrations of nitrate, nitrite, and hydroxide in each tank, review WCS.

Table 6. Maximum Temperature Limits For Bulk Waste Removal Tanks (See Note 1) With Nitrate Concentrations Less Than 1 Molar (M) (See Note 2).

Supernate Concentration	T_{sup}		T_{ss}, T_w	
Hydroxide (M)	$[NO_3^-] \leq 0.02$ M	$0.02 \text{ M} < [NO_3^-] < 1$ M	$[NO_3^-] \leq 0.02$ M	$0.02 \text{ M} < [NO_3^-] < 1$ M
$0.01<[OH^-] \leq 1$	75°C	75°C	$T_{ss} = 75°C$ $T_w = 70°C$	$T_{ss} = 75°C$ $T_w = 70°C$
$1 < [OH^-] \leq 8$	60°C	100°C	$T_{ss} = 60°C$ $T_w = 55°C$	$T_{ss} = 100°C$ $T_w = 95°C$
$[OH^-] > 8$	60°C	60°C	$T_{ss} = 60°C$ $T_w = 55°C$	$T_{ss} = 60°C$ $T_w = 55°C$

Note 1: Applicable to waste tanks being slurried for a period starting when one or more mixing pumps have operated at or above minimum speed for 3 hours or more. The temperature limit can be extended up to 30 days after the pumps/mixers are shutdown. Waste Tanks that are slurried with nitrate concentration greater than or equal to 1 M are subject to the limits in Tables 3 and 4.
Note 2: For the most recent concentrations of nitrate, nitrite and hydroxide in each tank, review WCS.

Compensatory Measures

The following required actions are designed to ensure that the time period over which a waste tank is susceptible to corrosion is minimized.

1. If the waste tank temperature does not meet the minimum requirements of Table 2 and/or exceeds the limits established in Tables 3, 4, 5, and 6, with the

exception of the supernate temperature limits for evaporator drop tanks during evaporator operations, the following shall occur:

A. CSTF Engineering (CSTFE) shall be notified by CSTF Operations (CSTFO) of the condition within 24 hours if Operations is unable to bring the temperature within limits before this time is expired.
B. CSTF Engineering shall provide, within 5 days of notification, an evaluation that includes suggested actions needed to bring the tank temperature into compliance with Tables 2, 3, 4, 5, and 6. The evaluation shall also include the expected time needed to perform necessary actions. If mixing pumps are in operation at the time the condition is recognized, Engineering shall assess whether they should continue operation. If the temperature is restored within the limits listed in Tables 2-6 before the 5 days have expired, engineering does not have to provide an evaluation.

2. If the thermocouple for the supernate, salt, and/or sludge phases is not functional, or if the thermocouple for the steel wall is not functional (or the magnetic thermocouple attached to the outside of the primary tank wall of Tanks 1-15 or 29-34 becomes detached), the following actions shall occur: (Only applies to Type I, II, III, and IIIA waste tanks, excluding evaporator drop tanks during evaporator operation)

   A. The thermocouple shall be restored to functionality, or an alternate (e.g., a representative one in an adjacent phase) thermocouple shall be used to monitor the temperature of the affected waste phase or steel wall within 7 days after the condition is noticed. The normal monitoring frequency shall continue with the alternate thermocouple if the thermocouple is not restored.
   B. If mixing pumps are in operation at the time of the thermocouple's failure, CSTF Engineering shall be notified to provide guidance on whether operation of the mixing pumps should continue.
   C. A functional wall temperature thermocouple shall be restored in the affected waste phase/tank steel wall within 45 days. If requirements cannot be met within the allotted time frame, a path forward shall be written for restoration and approved by the Facility Operations Safety Committee (FOSC).

3. If there are no functional or representative thermocouples available in a Type IV waste tank, the following actions shall occur:

   A. CSTF Engineering shall be notified if there are any mixing pumps in operation in the affected tank. Engineering shall provide guidance as to whether or not the mixing pumps should remain in operation.
   B. A representative thermocouple shall be functional in the tank within 30 days.

4. The maximum supernate temperature limit during salt dissolution processing

is 50 °C. This is lower than the current corrosion control program requirement at the estimated nitrate concentration for dissolved salt solutions (NO_3 > 1M). This lower temperature will further reduce the risk of corrosion. Laboratory testing at the expected inhibitor concentrations has indicated that the risk of significant corrosion at temperatures less than or equal to 50 °C, for short term exposures (e.g., less than 100 days) is low in these high nitrate solutions [Ref. 73].

Monitoring Frequencies

1. A heat load of 0.10 Btu/hr/gal in a waste tank, conservatively assuming the waste has the properties of water with no external heat removal, can produce a 5°C rise in temperature in a month. Heat loading would normally drive the required monitoring frequencies however, during normal operations it is checked daily per the DSA. For all active and inactive Type I, II, III, IIIA, and IV tanks, verify that the tank waste temperatures (supernate, salt, sludge, and steel wall as applicable) are no greater than the maximum temperature limits as listed in Tables 3, 4, 5, and 6 and steel wall temperatures do not go lower than the minimum requirements in Table 2 (as applicable) daily or every shift during slurry pump operation, unless an engineering evaluation justifies a longer frequency.
2. Perform an instrument loop calibration of thermocouples for each tank every 365 days.
3. For the active Type I, II, III, and IIIA tanks and inactive Type I, II, III, and IIIA tanks with heat loads above 0.10 Btu/hr/gal, ensure that the thermocouples used for reporting temperatures in each waste phase are reading representative phase temperatures every 90 days.
4. For the inactive Type I, II, III, and IIIA tanks with heat loads below 0.10 Btu/hr/gal, ensure that the thermocouples used for reporting temperatures in each waste phase are reading representative phase temperatures every 365 days.
5. Inspect the steel wall TCs for Tanks 1-15 and 29-34 and verify that they are attached to the steel primary wall within 3 feet of the bottom knuckle weld every 730 days.
6. Prior to each waste transfer and prior to operating mixing pumps, which have changed height, verify that there will be a functional, or functional alternate, thermocouple for each resulting waste phase. Operating (WTS, WTE) procedures shall ensure the compliance with this requirement.

5.1.2 CHEMISTRY CONTROLS

Chemistry Limits

In order to prevent corrosion, the appropriate amount of inhibitor must be present in the tank to sufficiently balance the nitrate concentration. The following table, Table 7, shows the required concentration of either hydroxide or nitrite for the

corresponding amount of nitrate in the waste tanks. The analytical uncertainties associated with the constituents of concern for the corrosion control program are within the conservatism applied in the establishment of those limits [60].

Table 7. Minimum Corrosion Inhibitor Concentration Limits

Applicability	Limit		Parameter	Minimum Needed	Units
5.5M < $[NO_3^-]$ ≤ 8.5M	1		$[OH^-]$	0.6	Molar
			$[OH^-] + [NO_2^-]$	1.1	Molar
2.75M < $[NO_3^-]$ ≤ 5.5M	2		$[OH^-]$	0.3	Molar
			$[OH^-] + [NO_2^-]$	1.1	Molar
1.0M ≤ $[NO_3^-]$ ≤ 2.75M	3		$[OH^-]$	$0.1[NO_3^-]$	Molar
			$[OH^-] + [NO_2^-]$	$0.4[NO_3^-]$	Molar
0.02M < $[NO_3^-]$ < 1.0M AND $[OH^-]$ < 1.0M (See Note 2)	4	4a	$[OH^-]$	1.0	Molar
			OR		
		4b	$[NO_2^-]$	$0.038 * [NO_3^-] * 10^{1\ 64}$	Molar
		4c	AND $[NO_2^-]$	$6.11 * 10^{[1.64+1.34 * \log[Cl-]]}$	Molar
		4d	AND $[NO_2^-]$	$0.04 * 10^{[1\ 64+0.84 * \log[SO4-2]]}$	Molar
		4e	AND pH	10.3	pH
$[NO_3^-]$ ≤ 0.02 M AND $[OH^-]$ < 1.0 M (See Note 2)	5	5a	$[OH^-]$	1.0	Molar
			OR		
		5b	$[NO_2^-]$ (if $[Cl^-]$& $[SO_4^{-2}]$ is not known)	0.033	Molar
			OR		
		5c	$[NO_2^-]$	$0.038 * [NO_3^-] * 10^{1\ 64}$	Molar
		5d	AND $[NO_2^-]$	$6.11 * 10^{[1.64+1.34 * \log[Cl-]]}$	Molar
		5e	AND $[NO_2^-]$	$0.04 * 10^{[1\ 64+0.84 * \log[SO4-2]]}$	Molar
		5f	AND pH	10.3	pH
Applicable to Tank 48 ONLY $[NO_3^-]$ ≤ 1.0M AND $[OH^-]$ < 1.0M	6	6a	$[NO_2^-]$	$0.91[NO_3^-]^{0.79}$	Molar
		6b	AND $[NO_2^-]$	$1.5 * 10^{[1.35+1\ 03 * \log[Cl-]]}$	Molar
		6c	AND $[NO_2^-]$	$1.5 * 10^{[-0.22+0.61 * \log[SO4-2]]}$	Molar
Influents to waste tanks from other areas on site (See Note 1).			pH	9.5	pH

Note 1: Waste Acceptance Criteria provides the means for controlling the pH of influents to the tank farm. These influents do not include rainwater, raw water flushes, etc.
Note 2: The inhibitor requirements in Limits 4 & 5 are based upon a supernate temperature of 40°C.
Note 3: Tanks designated as being in the Cleaning Activities Life Cycle are exempt from the inhibitor requirements shown in this table.

Sampling Schedule

In order to assure that the chemistry in each tank stays within the limits given in Table 7, every tank's supernate must be sampled periodically. A 30 day grace period is permitted in meeting this frequency. Table 8 identifies the frequency with which a tank must be sampled, based on that tank's status and last known chemistry. If a tank has been sampled 15 times since receiving waste in a waste tank to waste tank transfer and the statistical capability of the tank to meet the minimum corrosion inhibitor limits (Sigma Level) can be established, the sample frequency shall be determined from Table 9. In either case, the sample frequency for each tank shall be noted in the ERD. The PassPort system, or its equivalent, shall be utilized to ensure that the samples are taken to meet the requirements of this section.

Table 8. Sample Frequency For Waste Tanks

Status	Category	Inhibitor Levels	Frequency
ACTIVE WASTE TANKS	Evaporator Feed And Drop Tanks	$[NO_3^-] < 1M$ or $[OH^-] < 2.35M$ or $[S] < 3M$	90 days
		$[NO_3^-] \geq 1M$ or $[OH^-] \geq 2.35M$ or $[S] \geq 3M$	180 days
	Fresh Canyon Waste Receiver with Nitrate Concentration Greater Than or Equal to 1M	$[OH^-] < 3M$ or $[S] < 4M$	180 days
		$[OH^-] \geq 3M$ or $[S] \geq 4M$	365 days
	Receiver with Nitrate Concentration Less Than 1M	$[NO2^-]/[NO3^-] < 3.4$ or $[OH^-] < 0.02M$	90 days
		$3.4 \leq [NO2^-]/[NO3^-] < 4.8$ and $0.02M \leq [OH^-] < 2.35M$	180 days
		$[NO2^-]/[NO3^-] \geq 4.8$ or $[OH^-] \geq 2.35M$	365 days
	Receiver with Nitrate Concentration Greater Than or Equal to 1M	$[OH^-] < 2.35M$ or $[S] < 3M$	180 days
		$2.35M \leq [OH^-] < 3M$ and $3M \leq [S] < 4M$	365 days
		$[OH^-] \geq 3M$ or $[S] \geq 4M$	730 days
	Bulk Waste Removal Tanks	N/A	30 days
	Sludge and Salt Feed Tanks	NA	730 days
INACTIVE WASTE TANKS	Nitrate Concentration Less Than 1M	$[NO_2^-]/[NO_3^-] < 3.4$ or $[OH^-] < 0.02M$	180 days
		$3.4 \leq [NO_2^-]/[NO_3^-] < 4.8$ and $0.02M \leq [OH^-] < 2.35M$	365 days
		$[NO_2^-]/[NO_3^-] \geq 4.8$ or $[OH^-] \geq 2.35M$	730 days
	Nitrate Concentration Greater Than or Equal to 1M	$[OH^-] < 2.35M$ or $[S] < 3M$	365 days
		$2.35M \leq [OH^-] < 3M$ and $3M \leq [S] < 4M$	730 days
		$[OH^-] \geq 3M$ or $[S] \geq 4M$	1460 days
Chemical Receipt Tank	Chemical Cleaning Activities	Compliant with Table 7	90 days

$S = [OH^-] + [NO_2^-]$

Table 9. Sample Frequency for Waste Tanks Based on Statistical Analysis	
Inactive Tanks with Nitrate Concentrations Less Than or Equal to 1 Molar and Active Tanks	
Sigma Level	Frequency
0 - 2.99	90 days
3.00 - 3.49	180 days
3.50 - 3.99	365 days
4.00 or greater	730 days
Inactive Tanks with Nitrate Concentrations Greater Than 1 Molar	
Sigma Level	Frequency
0 - 2.99	180 days
3.00 - 3.49	365 days
3.50 - 3.99	730 days
4.00 or greater	1460 days

If the sample frequency is increased such that the next required sample is past due, then the next sample should be scheduled within a grace period of 30 days from the date that the new sample frequency is noted in the ERD. The sampling frequency for a slurried BWR tank can be extended only by an engineering evaluation. This evaluation must discuss the possible risks of extending the frequency and must provide adequate justification of the risks. The Facility Manager's concurrence with this evaluation shall provide the necessary authority to extend that tank's sampling frequency.

An engineering evaluation may be performed to allow the exclusion of a tank undergoing waste removal activities from this sampling frequency schedule. Such an evaluation must demonstrate that the risk of corrosion in the tank is minimal and explain any actions needed to retain the integrity of the waste tank (i.e., inhibitor additions). This evaluation should estimate the amount of corrosion that would occur during the time period between its exit from the sampling schedule until it is closed. If the evaluation shows that the tank wall integrity will not be lost during the anticipated time frame, that tank can be exempted from the program. The evaluation should also discuss the need to increase annulus leak detection monitoring. The concurrence of the Facility Manager on such an evaluation will automatically exempt that tank from the sampling frequencies shown above. If any of the assumptions (i.e., timeframe, chemistry, etc.) change after the evaluation is written, the tank must be re-evaluated using the new conditions to determine whether it is still safe to remove the sampling frequency requirements.

The Extended Sludge Processing (ESP) (i.e., Tanks 40 and 51) tanks are well characterized and all incoming streams are known. These tanks are treated as "receiver" tanks rather than Bulk Waste Removal tanks.

Water Additions to Waste Tanks

During normal operations of the tank farms, water must be added occasionally to a waste tank as a result of some form of flushing. These water additions could potentially change the chemistry of the waste tank and present a possibility for the chemistry to fall outside the limits set in Table 7. If more than 3,000 gallons of water are to be added to a tank, a pre-evaluated transfer approval form (pre-ETAF) or an engineering evaluation shall be completed. This evaluation should discuss the ramifications of adding large amounts of water to the tank and should also provide any necessary compensatory measures such as sampling or chemical additions. If the receipt tank has a specific gravity higher than 1.20, the evaluation should also discuss the possibility of stratification, and provide guidance on restoring the chemistry within the established limits.

Compensatory Measures

The following actions are required in order to minimize the risk of corrosion in a waste tank.

1. If the hydroxide and/or nitrite concentrations are outside the corrosion inhibitor limits shown in Table 7 the following actions shall be taken:

   A. CSTFE shall provide CSTFO guidance regarding the continuance of waste transfers and the continued operation of mixing pumps. This guidance shall be given within 24 hours.
   B. The chemistry in the tank shall be restored and/or a sample pulled within 45 days to verify the chemistry is within the required limits, unless an extension is justified by an engineering evaluation. This action may require the addition of corrosion inhibitors and/or concentrated supernate.

      - If the chemistry is restored in a well-mixed tank (one mixing pump operating for a total of 8 hours) or Evaporator Drop Tank, compliance can be justified by a material balance evaluation.
      - If the chemistry is restored through diffusion or pump recycles, a sample is required to verify restoration. CSTFE shall provide direction concerning chemical additions and sample verification of the supernate.

2. If a Type III/IIIA tank waste chemistry is outside of the inhibitor or temperature requirements for more than 3 months a UT examination of a

single, random vertical strip and a previously inspected area shall be performed within one calendar year of the date the tank chemistry was determined to be noncompliant [Ref. 72]. For Type III/IIIA tanks that are undergoing Salt Dissolution, a UT examination is required if the tank chemistry is out of compliance and the liquid air interface is stagnant for more than 3 months.

3. If the liquid level in an inactive waste tank increases by greater than 3,000 gallons during the period of 30 days (checked once every 30 days), not related to transfers, Engineering shall provide an evaluation to determine the need for any remedial action within 5 days.

4. For additions of water greater than 3,000 gallons, a pre-ETAF or engineering evaluation shall be provided prior to issuing a data modification tracker (DMT) for the execution of the water addition.

5. Waste tank corrosion samples shall be pulled at the frequency specified in Tables 8 and 9 and tracked in the ERD. A 30 day grace period is applicable for this. This 30 day grace period is also applicable when an increase in sample frequency results in a sample which is overdue. If the 30 day grace period will not be met, Engineering shall specify remedial actions and required timing.

6. Completion of corrosion sample analysis is required within 90 days of the date that the sample was pulled and shall be tracked in the ERD. A 30 day grace period is applicable to this requirement. If the 30 day grace period will not be met engineering shall specify remedial actions and required timing.

7. Minimizing the time noncompliant chemistry is stagnant during salt dissolution will mitigate the risk for pitting at the liquid air interface in a salt dissolution tank and mitigate the risk for nitrate stress corrosion cracking in a dissolved salt solution receiver tank for a Type III/IIIA tank that has been stress relieved. Salt dissolution processing strategy shall be implemented and controlled through Operating Procedures.

   A. The maximum allowable dissolution time is 4 weeks. Dissolution time being from the completion of the water addition into the tank to the start of the next water addition.
   B. The maximum allowable stagnant time in a dissolved salt solution receiver tank is 4 weeks.
   C. A transfer out or liquid addition of 6 inches or greater can reset the dissolution time or stagnant time.
   D. If the dissolution or stagnant time goes beyond 4 weeks an action plan for inhibiting the free liquid above the salt cake shall be implemented and

completed within 45 days.

E. A confirmation sample shall be taken to verify that the supernate chemistry at the liquid air interface is in compliance with Table 7.

For non-stress relieved Type I, II, or IV salt dissolution receiver tanks:

F. Dissolved salt solution shall not be transferred into a Type I, II, or IV waste tank unless the chemistry of the dissolved salt solution has been determined by a sample and/or flowsheet evaluation.

G. If the sample result shows that the waste is within the current inhibitor requirements, the dissolved salt solution may be transferred.

H. If the sample result shows that the waste is not within the current inhibitor requirements, the dissolved salt solution receiver tank may be pre-conditioned prior to the transfer so that the final composition of the waste in the dissolved salt receiver tank meets the current inhibitor concentration requirements. An evaluation to determine the amount of inhibitor needed to pre-condition the tank will be necessary as well as any mixing requirements.

Monitoring Frequencies

The following monitoring activities are required to ensure that each tank complies with the chemistry limits established in Table 7 and is monitored in accordance with Tables 8 and 9.

1. Each tank that contains liquid waste shall be periodically sampled in accordance with Table 8 & Table 9. The sample frequency dictated by Table 8 & Table 9 shall be shown in the ERD. The ERD must be updated when these frequencies change.

2. All dry salt tanks shall receive an annual video inspection to ensure tank conditions have not changed. The video inspection frequency shall be tracked by tickler or in the Passport system or its equivalent to ensure requirements are being met.

3. Prior to each waste tank to waste tank transfer, verify that the corrosion inhibitors of the receiving tank will remain within the limits established in Table 7 after the transfer is completed or perform an engineering evaluation to provide a technical justification to authorize temporarily taking the tank out of strict compliance with Table 7.

Evaporator Tube Bundle Corrosion Control

The evaporator tube bundle shall be submerged in an inhibited solution, as defined in the background section of this program, within 30 days of the removal of waste from the

evaporator pot. A failed tube bundle that is deemed OOS with no intention for return to service is exempt from the corrosion protection requirements.

Compensatory Measures
If more than 30 days elapse before the tube bundle is submerged in an inhibited liquid (as defined in the background section of this program), hydrotesting of the tube bundle must be performed to verify the integrity of tube bundle within one week prior to restarting the evaporator.

Prevention of Microbiologically Influenced Corrosion (MIC) in Transfer Lines, Evaporator Systems and Waste Tanks

Waste Tanks are protected from MIC due to the typically high hydroxide levels, salt levels, radiation fields, and non-stagnate conditions. Transfer lines and evaporator systems must be protected from conditions that could lead to MIC. The following measures ensure that these conditions do not occur.

Compensatory Measures

1. If there is a known "low" point in a transfer line, as shown in the SI program, and a flush is required, use inhibited water (pH>12) to flush that transfer line, unless another waste transfer is planned through that line within the next 5 days. If a line is flushed with uninhibited well water because another transfer is anticipated and that anticipated transfer does not occur, the line shall be flushed with inhibited water before the 5 days have expired.

Cooling Coil Corrosion Control

Cooling coils must be protected, both from the interior and exterior, from corrosion. The exterior of the cooling coils is protected by the chemistry and temperature limits imposed on the waste in each waste tank. The following compensatory measures and monitoring activities are intended to reduce the failure of cooling coils due to internal corrosion. A cooling coil that has failed leak testing and is deemed OOS by the Facility Manager is exempt from the cooling coil protection requirements.

Compensatory Measures

1. All functional, isolated cooling coils shall be flushed with chromate cooling water every 90 days, if not designated as a waste tank in Closure Mode.

Monitoring Frequencies

1. Chromate cooling water shall be sampled every 90 days to ensure that the chromate level in the water is sufficient to inhibit corrosion (>450 ppm).

Vapor Space Corrosion Controls

Table 10 provides supernate chemistry control limits for a tank that is inactive for more than six months [70]. If the tank is active during the six month period, the limits in Table 7 remain applicable. These limits apply only to Type III/IIIA tanks. Compliance with these limits will be accomplished by quarterly engineering evaluations to identify any tanks that may not be compliant with the vapor space criteria.

Table 10 – Minimum Chemistry Requirements for Tanks That Have Been Inactive for More than Six Months

Applicability	Parameter	Minimum Needed (M)
$1 < [NO_3^-] \leq 8.5$	$[OH^-]$	1
	AND $[NO_2^-]$	0.2
	OR	
	$[OH^-]$	0.6
	AND $[NO_2^-]$	0.6
	AND $[NO_2^-]$	$6.11*10^{(1.64+1.34*Log([Cl-])}$
	AND $[NO_2^-]$	$0.04*10^{[1.64+0.84*Log([SO4-])]}$

Compensatory Measures

1. If any Type III/IIIA tank is discovered not to be in compliance with the vapor space program during the development of the quarterly vapor space corrosion report, the following action shall be taken:
   A. The quarterly vapor space corrosion report will recommend actions to bring the tank(s) back into compliance with the vapor space corrosion criteria provided in Table 10.

Tanks in the Cleaning Activities Life Cycle are exempt from these requirements.

5.1.3 HUMIDITY CONTROL

Steam Supply to Ventilation

Steam shall be supplied to the annulus ventilation pre-heater in order to heat the air in the annulus. By heating the air in the annulus, the risk of corrosion due to condensation is eliminated. Every week (7 days) a check shall be made to ensure that each annulus ventilation system is receiving steam and that each annulus ventilation system is operating.

If the steel wall temperature of the tank is above 40°C (lowest steel wall temperature reading), there is no requirement for the operation of steam, unless liquid is detected in the annulus. Waste tanks are required to have an annulus conductivity probe ≤ 1 inch above the annulus floor (excluding Type IV waste tanks) unless existing waste is limiting placement, at which point the waste will serve as the floor level (Not to exceed TSR requirements). Tanks preparing to undergo waste removal are exempt from this requirement and may raise the annulus conductivity probe ≥ 1 inch above the annulus floor (Not to exceed TSR requirements). Level exemptions for waste removal shall be implemented and controlled through Operating Procedures. In the event liquid is detected, steam shall be used until the annulus is dried.

Tanks in the Final Stabilization Preparation Life Cycle designated as Closure Mode are exempt from these requirements.

Compensatory Measures

1. If the annulus ventilation is not in operation or steam is not supplied to the annulus pre-heater and the tank steel-wall temperature is below 40°C, these conditions shall be corrected within 30 days for the Type I and II tanks and within 90 days for the Type III and IIIA tanks. If no steam is available, the ventilation shall be operated continuously (as long as the tank wall temperature is above the low operating limit on the roundsheets). If requirements cannot be met within the allotted time frame, a path forward shall be written for restoration and approved by the FOSC.

2. If liquid is detected in the annulus or if the annulus does not contain a functional conductivity probe, the following action shall be taken:

   A. If liquid is verified to be in the annulus, the ventilation system shall be operated with steam supplied to the annulus pre-heater and Engineering shall be notified. This action shall be completed within 24 hours.

   B. The liquid level shall be tracked until non-detectable. If the liquid level does not decrease within 48 hours of ventilation operation with steam to the pre-heater, continue to rise, and/or ventilation is not operable with steam, Engineering shall provide a path forward to address meeting structural integrity fill limits within 5 days.

Monitoring Frequencies

1. Annulus conductivity probe level shall be verified annually to ensure that the probes are ≤ 1 inch above the annulus floor or waste level in the annulus (not to exceed TSR limits). The verification frequency shall be tracked by tickler or in the Passport system or its equivalent to ensure requirements are being met.

5.2 *Cleaning Activity Life Cycle*

During the Cleaning Activities Life Cycle, the program allows for the suspension of corrosion inhibitor concentration requirements, sampling frequencies, and maintaining annulus ventilation requirements for up to 1460 days for waste removal activities. Since the life cycle is short, the corrosion controls imposed are greatly diminished, but are adequate to ensure that sufficient tank integrity remains to complete the closure process. Corrosion control compensatory measures and monitoring frequencies, as stated during Normal Operations for MIC and Cooling Coils still apply.

5.2.1 TEMPERATURE

Maximum Limits

In assessing the waste storage tanks, going through the cleaning activities life cycle stage, temperature was an important variable for estimation of the expected

corrosion rates during waste removal activities [1] therefore, maximum supernate temperature limits and the associated temperature compensatory measures and monitoring frequencies are applicable during the Cleaning Activities Life Cycle. Bounding temperatures for each of the activities were assumed for the analysis. The maximum temperature experienced during bulk sludge removal due to mechanical heat generated by mixing devices is expected to be 60°C. The maximum temperature for salt dissolution is expected to be 50°C. The maximum temperature in tanks storing salt cake is also approximately 50°C [23]. Additionally, salt dissolution is an endothermic process, which lowers the temperature of the waste below 50°C [24]. An engineering evaluation or an approved operating plan for a particular waste tank can exempt a tank from these temperature controls. The evaluation or operating plan must provide justification for the relaxation of controls and must be properly reviewed and approved. The maximum supernate temperature limit for oxalic acid addition during Acidic Chemical Cleaning is 75 ºC. The target temperature for heel removal with oxalic acid is 50 °C [1]. However, the reaction between the oxalic acid and the sludge is exothermic and the mixer pumps will also add mechanical heat to the system [1]. Therefore a reasonable maximum temperature for the oxalic acid chemical cleaning process will be 60 °C. There are NO exemptions allowed for maximum supernate temperature limits during Acidic Chemical Cleaning.

Minimum Temperature Limits

During Chemical Cleaning of Type I/II waste tanks, the concrete vault and, in the case of the Type I tanks, the concrete columns are credited for structural integrity controls for normal operation and natural phenomena events. The steel tank wall is not credited and therefore embrittlement of the primary tank wall is not an issue. Type I/II Chemical Cleaning Waste Tanks are exempt from NDTT requirements in Table 2 [62].

Compensatory Measures

1. The initial supernate temperature for an Acidic Chemical Cleaning Treatment Tank prior to oxalic acid addition shall be < 60 ºC. If the supernate temperature reaches 60 ºC, valve in cooling coils to cool the supernate below 60 ºC. If the supernate temperature during oxalic acid addition reaches 70 ºC, stop acid addition to the treatment tank and notify CST Engineering for guidance. The effects of instrument uncertainty or accuracy shall be accounted for during comparison to these limits.

2. If the maximum supernate temperature limits for sludge removal (60°C) and salt dissolution (50°C) during the Cleaning Activities Life Cycle are exceeded, stop mixing devices and transfers out of the tank until the temperatures conform to the required limits. The effects of instrument uncertainty or accuracy shall also be accounted for during the comparison of the acidic chemical cleaning temperature limit.

Monitoring Frequencies

1. Acidic Cleaning are very low-volume operations or involve mixing pumps at high volumes. The highest temperatures are likely during the slurrying process, when the pumps are adding heat to the tank and may challenge temperature limits. Consequently, temperature shall be monitored every shift when the mixing pumps are operating. After the slurrying process, the mixing devices are turned off and most of the heat-generating sludge-slurry mixture is transferred out of the tank. Therefore, it is expected that the temperatures will not challenge the limits during low-volume phase of the process.

5.2.2 CHEMISTRY

For waste tanks designated in the Cleaning Activities Life Cycle stage, sampling of the waste for corrosion control purposes is suspended during waste removal activities. The limits in Tables 7, 8, 9, and 10 do not apply. The analysis [1] assumes a total of 1460 days of closure activities which includes 365 days of chemical cleaning (Feeding 4 to 8 wt% oxalic acid at 60 to 75°C with no mixing for ≤ 30 days and the remainder of time at ≤ 4 wt% oxalic acid at 60°C).

Acidic Chemical Cleaning Waste Tanks

Prior to acidic chemical cleaning, the sludge volume in the Treatment Tank shall be verified to be less than or equal to 10,000 gallons by an engineering evaluation. An evaluation shall be performed to verify a maximum of 20:1 volume ratio of 8 wt% oxalic acid to sludge utilizing mapping, historical data, and/or visual inspection. Acidic Chemical Cleaning is not allowed in Tank 1 [62].

Acidic Chemical Cleaning Transfer Path

Applicable pump tanks in the transfer path shall be pre-conditioned with supernate, sodium hydroxide or other inhibitor to neutralize the acidic waste being added to it. Implementation is controlled by the Waste Tank Chemical Cleaning Program [62]. Once a chemical cleaning transfer has occurred in a transfer line, the affected transfer line must be vented and drained. If a transfer line has received acidic chemical cleaning solution, flushing is required using inhibited water (pH ≥ 12).

Chemical Cleaning Receipt Tanks

In addition to the chemistry limits provided in Table 7, chemical cleaning receipt tanks shall comply with the following requirements imposed by the Waste Tank Chemical Cleaning Program [62]:

1. The chemical receipt tank shall be pre-conditioned with supernate, sodium hydroxide or other inhibitor to neutralize the acidic waste being added to it; and,
2. At least one mixing device shall be operating prior to and during the addition of acidic waste to ensure neutralization of the acidic waste to protect corrosion of the receipt tank.
3. Addition of acidic waste shall enter the receipt tank via a flow path below the waste tank liquid level. However, vent and drain operations into Tank

51 are permitted to receive acidic waste above the liquid level due to limited volume.

Compensatory Measures

1. The treatment tank shall be exposed to 8 wt% oxalic acid at 75 ºC for ≤ 30 days. If 8 wt% acid addition activities extend beyond a total of 30 days for acidic chemical cleaning activities:
   A. Perform a risk assessment (e.g., engineering evaluation, utilizing process history, ultrasonic inspection, etc.) of the primary tank wall loss
   B. The risk assessment can be used to extend the time 8 wt% acid is in the tank, if warranted.
   C. The allowance for tanks being exposed to 8 wt% oxalic acid at 75 ºC for 30 days for acid addition shall be tracked separately from the 365 day allowance for Chemical Cleaning activities in the Tank Farm Morning Report or LCO Tracking Database.

2. The Cleaning Activities Life Cycle allows for the suspension of corrosion inhibitor concentration requirements, sampling, and maintaining annulus ventilation requirement for up to 1460 days and shall be tracked in the ERD. The allowance for tanks being exposed to oxalic acid for 365 days (Feeding 4 to 8 wt% oxalic acid at 60 to 75°C with no mixing for ≤ 30 days and the remainder of time at ≤ 4 wt% oxalic acid at 60°C) and for acidic chemical cleaning activities shall be tracked separately in the Tank Farm Morning Report or LCO Tracking Database. If waste removal activities extend beyond a total of 1460 days or more than 365 days for acidic chemical cleaning activities:
   A. Perform an ultrasonic inspection of the primary tank wall and an engineering evaluation within 180 days of exceeding the time limit. The extent and scope of the inspection shall be determined by the Liquid Waste In-Service Inspection Review Committee (ISIRC) [1].
   B. The engineering evaluation can be used to extend the time, if warranted.

5.2.3 HUMIDITY

Annulus ventilation is not required for waste tanks in the Cleaning Activities and Final Stabilization Preparation Life Cycle because significant corrosion degradation due to intermittent condensation on the tank wall is not anticipated during the short-term closure process [1]. However, annulus ventilation is a credited control imposed by the Flammability Control Program.

5.3 *Final Stabilization Preparation Life Cycle*

Active corrosion protection for waste storage tanks in the Final Stabilization Preparation stage is not required and the tank is exempt from the Corrosion Control Program DD controls.

An assessment has determined that the seismic integrity of Type I Waste Tanks (Type II Waste Tanks are bounded by Type I Waste Tanks) in this phase is acceptable accounting for a 100,000 gallon well water fill limit and a 10 year delay in grouting which equates to an additional 100 mil wall thickness reduction [63]. Administrative controls require the tank be stabilized within 10 years. In the unlikely event that the tank is not grouted within 10 years of the Closure declaration, an engineering evaluation for structural and leak integrity shall be performed on the tank to ensure that the intended safety class function is met. The approach to the evaluation may be similar to that of the realistic scenario calculation provided in Reference 1. Actual exposure time, liquid levels, temperature, and corrosive environment should be considered.

A fracture assessment demonstrated that the risk of brittle fracture for Type I and II tanks in the Final Stabilization Preparation Life Cycle designated as Closure Mode is unlikely. Therefore, the thermocouple attached to the exterior of the tank wall, utilized to monitor the steel wall temperature maybe removed once a tank has been declared to be in Closure Mode. The conclusion that the brittle fracture was unlikely for non-stress relieved tanks with higher minimum operating temperatures can be naturally extended to conclude that Type III/IIIA tanks with lower minimum operating temperatures have even lower risk of brittle fracture during Closure mode.

6.0 References

1. K. B. Martin, “Evaluation of the Impact of Removing Corrosion Controls During Waste Tank Closure Activities”, C-ESR-F-00041, Rev. 5, March 21, 2013.

2. G-TRT-G-00003, Appendix 6, Corrosion Control Program.

3. G-TRT-G-00003, Appendix 9, Structural Integrity Program.

4. B.J. Wiersma, “Determination of Temperature Limits for Radioactive Waste Tanks (U)”, WSRC-TR-98-00131, April 22, 1998.

5. B.J. Wiersma, "Clarification of Temperature Limits with Nitrate Concentrations Greater than 1 Molar", WSRC-TR-94-0333, August 8, 1994.

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CSTF Evaporator Feed Qualification Program

Program Description Document

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Summary of Revisions

02/03 - Revision 0; Initial Issue

03/03 - Revision 1;

Revised Section 2.0 to clarify output documents general requirements; Clarified requirement 4.3.1.iii to exclude the drop tank; Included Sample Protocol reference; Clarified that the inadvertent transfer requirements apply only to HEU transfers.

03/04 - Revision 2;

Added technical basis to section 4.1 for evaporator bottoms hydrogen generation rate that shows that it is bounding and removed implementation action to verify through WCS; added interpretation to section 4.2 for 6 month requirement to determine NAS formation rate and silicon concentration; added discussion to 4.3 to state that 299-H material is no longer an accepted feed to the 2H system; added clarification to section 4.3 for monthly enrichment sample requirements and detailed action when samples are greater than 51 days old.; added clarification to section 4.3 concerning the 120 g monthly limit of U-235 from the GPE; clarified that Tank 43 Flygt mixers have been electrically disconnected; other editorial changes highlighted with revision bars

05/07 - Revision 3;

Clarification of the requirements in section 4.3.1 in the event approved enrichment sample results for Tank 43 are greater than 51 days old based on the pull date of the previously DIRT approved sample and in the event an enrichment sample for Tank 43 has not been taken in the last 30 days.

03/08 Revision 4

In Section 4.3.1, removed Tank 23 from the list required for annual enrichment control program (ECP) sampling. Added that the transfers from Tank 23 directly into the 242-16H Evaporator System are prohibited.

10/08 Revision 5

In Section 4.3, revised the entire section in accordance with the new Operation of the 2H Evaporator System Nuclear Criticality Safety Evaluation (2H NCSE).

10/09 Revision 6

In Section 4.3, removed the annual sampling requirements of Tanks 21, 22 and 24 based on discussions in the 2H NCSE.

3/10 Revision 7

In Section 4.3.1, removed Tank 21 and Tank 24 as the Tank Farm waste tanks storing influent waste streams for future processing through the 242-16H Evaporator System.

5/14 Revision 8

General format change per S4 Eng.36 procedure

Added Table of Contents

In Section 4.1, seperated the bounding hydrogen generation rate for evaporator feed/bottom in 242-16F/H and 242-25H from the bounding hydrogen generation rate for scale in 242-16H. Addressed the conservatism for the bounding hydrogen generation rate for scale in 242-16H and removed the implementation requirements and actions to protect the bounding hydrogen generation rate for scale.

In Section 4.2.1, defined parameters used to calculated NAS.

In Section 4.2.2, added criteria for transfers to 242-16F or 242-25H Evaporator System from a waste tank containing DWPF recycle or similar waste and criteria for removing a waste tank containing DWPF recycle or similar waste from ERD Table G-4. Added the visual inspection and evaluation requirements for the 242-16F/242-25H evaporator pots.

In Section 4.3.1, clarified Section 4.3 is only applicable to the 242-16H evaporator system. Clarified that prior to transfers of a non-DWPF recycle into Tank 22 or waste other than recycle transfers and Tank 22 to the 242-16H evaporator system (feed/drop tanks), a pre-transfer evaluation is required to determine the U-235 (eq) enrichment and the Pu content of the transfer waste using sample results of the individual waste stream making up the waste batch or the blended waste batch. The ETAF shall verify that the addition has an U-235 (eq) enrichment of $\leq$ 5.5 wt% and plutonium content of fissionable elements $\leq$ 2 wt%. Added equations to calculate the U-235 (eq) enrichment and Pu content. Added the requirement to communicate the enrichment results.

In Section 4.3.2, added the 2 wt% Pu content requirement in addition to the U-235 (eq) enrichment to satisfy the Enrichment Control Program.

In Section 4.3.3, added requirements to monitor accumulated scale in 242-16H evaporator pot and to update Tank Farm Morning Report

Added Section 5.0

Added References 22 thru 24.

Other editorial changes were highlighted with revision bars.

12/14 In Section 4.2.2.4, added action if sampling for 242-16F and 242-25H Evaporator systems cannot be performed within the required frequency.

In Section 4.2.2.6, removed action to not approve the transfer of DWPF Recycle or similar waste into 242-16F and 242-25H if one of the criteria listed in 4.2.2.6.1 thru 4.2.2.6.5 is not met.

In Section 4.2.2.7, added wording to include Section 4.2.2.6 implemenation action.

10/15 Revision 10
In Section 1.0, clarified requirements to perform DATR and USQ.
In Section 4.2.2.4, added requirements of multiple samples for feed and drop tanks. Clarified evaporator shut down requirements. Separated the required actions for feed and drop tanks if the determination of Si and NAS is not performed within the required frequency.
In Section 4.2.2.6, clarified analytical uncertainty does not need to be included in EFQ evaluation.
In Sections 4.2.2.7, 4.2.2.9, and 4.3.2.1, clarified evaporator shut down requirements. Deleted restart capability after FOSC and DOE approval.
In Sections 3.2.2, rephrased the requirement.
In Section 3.2.2, added requirement that Morning Report tracks the pot inspection due date and the remaining operation hours.
In Section 4.5, added management checklist requirement.
In Section 4.3.4, clarified the maximum subcritical NAS deposit
Updated references.

11/17 Revision 11 – 2017 DSA annual update and editorial changes
Section 2.0 - Added other Safety Basis controls defined in WSRC-IM-94-10 Section 3.0.
Sections 3.0 & 4.0
- Removed applicability of controls associated with 242-16F
- Added references to associated implementation actions.
Updated references.

5/18 Revision 12
Section 4.3 - Added steps for calculating sampling and analytical uncertainty for scale samples
Corrected table numbers
Updated references

6/18 Revision 13
Section 2.0 - Recognized DSA Addendum as another CSTF Safety Basis Document

Section 4.1.1 - Removed the bounding hydrogen generation rate for 3H Evaporator Bottoms
Added Section 4.4 – Added the minimum supernate nitrite concentration for the 3H Evaporator feed tank and the bounding hydrogen generation rate for 3H Evaporator Bottoms
Updated references

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1.0 PURPOSE

The purpose of this program description document is to provide background information and describe the key attributes of the Evaporator Feed Qualification (EFQ) Program.

The output documents generated by this Program Description Document (PDD) shall ensure independent verification or validation of results and conclusions. Output documents include, but are not limited to, calculations, procedures and technical reports.

Calculations issued as output documents shall be confirmed by Type I calculations in accordance with the requirements of the E7 Manual, Procedure 2.31A. Technical Reports issued as output documents shall comply with the requirements of E7 Manual, Procedure 3.60. If a Design Authority Technical Review (DATR) is required per E7 Manual, Procedure 2.31A, the assumptions and recommendations from these reports shall be addressed in the DATR written against the Proposed Activity. Additionally, the output documents will be included in the Unreviewed Safety Questions (USQ) review process for the Proposed Activity per Manual 11Q, Procedure 1.05.

1.1 PDD Owner Qualifications:

The qualifications for PDD ownership shall be conformed to the requirements established in S4 Manual Procedure Eng.36.

1.2 PDD Owner Responsibilities:

The PDD Owner Responsibilities shall be conformed to the requirements established in S4 Manual Procedure Eng.36.

2.0 SCOPE

The scope of this PDD is to provide guidance to engineering and operational personnel for implementing the EFQ Program related controls contained in the Documented Safety Analysis (DSA), Technical Safety Requirements (TSR), or other Interim Safety Basis documents defined by WSRC-IM-94-10 Section 3.0 (e.g., Justification for Continued Operation (JCO), Potential Inadequacy in the Safety Analysis (PISA), **DSA Addendum,** and Evaluation of the Safety of the Situation (ESS)). This document is not a Safety Basis document.

The 242-16F **E**vaporator's status has changed to an inactive location. Therefore, the 242-16F **E**vaporator is excluded from the EFQ Program.

3.0 BACKGROUND

The safety function of the EFQ Program is to ensure that the composition of waste streams received into the evaporator feed tanks is within analyzed limits prior to transfer

to the evaporator pot. Ensuring that the waste composition is within analyzed limits ensures that the assumptions made in the safety analysis are maintained.

The key attributes of this program necessary to ensure that the assumptions made in the safety analysis are maintained are:

3.1 Hydrogen Generation Rate

The EFQ Program sets the hydrogen generation rate for the evaporator feed, evaporator bottoms, and evaporator pot scale to keep flammable vapors below flammability limits in the vapor space.

3.2 Sodium Aluminosilicate (NAS) Scale Formation Rate

The EFQ Program controls the composition of waste streams received into the 242-25H **E**vaporator in order to prevent the formation of NAS scale in the evaporator thus eliminating the criticality and flammability concerns caused by the adherent sodium diuranate.

3.3 Evaporator Enrichment and Flammability Monitoring

The EFQ Program ensures that the total accumulated scale in the 242-16H **E**vaporator is less than or equal to 200 gallons to protect the DSA hydrogen producing NAS scale volume of 300 gallons. This prevents flammability concerns in the evaporator pot. The evaporator feed enrichment is maintained by the Operation of the 2H Evaporator System Nuclear Criticality Safety Evaluation (2H NCSE) [Ref. 16] such that a criticality in the evaporator is not credible.

4.0 PROGRAM DESCRIPTION

4.1 Hydrogen Generation Rate

4.1.1 Radiolytic Hydrogen Generation Rate for 242-16H Evaporator Feed and Evaporator Bottoms

Direct radiolytic hydrogen release to the vapor space is a primary contributor to the total flammable vapor concentration in an evaporator pot and evaporator cell [Ref. 1]. The radiolytic hydrogen release rate in the evaporator pot will be calculated using bounding generation rates for expected feed.

Hydrogen is produced in the tank farm waste by radiolysis of water. The hydrogen generation rate for a given waste depends on the radiolytic heat load of the waste and the concentration of any hydrogen scavengers that serve to decrease the overall production of hydrogen. The methodology used to calculate the hydrogen generate rate for a given waste is described in Ref. 22.

The bounding radiolytic hydrogen generation rate for evaporator feed and evaporator bottoms (242-16H) is 9.6E-6 ft^3/hr·gal [Ref. 1], which was derived using conservative assumptions such as high Cs-137 content, low NOeff, and 1 **weight percent (**wt%**)** sludge solids. The following provides further support for the derived bounding hydrogen generation rates.

- The current waste tank supernate inventory will meet the evaporator bottoms hydrogen generation limit for transfers into the 242-16H **E**vaporator. The established DSA limit was determined based on the bounding conditions for supernate and sludge coupled with an allowance for hydrogen scavenging (NOeff of 1.0 M) [Ref. 2]. These bounding conditions (including an allowance of 1 wt % sludge solids in the evaporator bottoms) prevent the hydrogen generation rate from being exceeded due to evaporation.
- The bounding hydrogen generation rate for evaporator bottoms is mainly due to the high Cs-137 content in the bounding supernate stream (with 1 wt% solids) designation [Ref. 2]. This Cs-137 activity of 42 Ci/gal is twice the content of any waste tank supernate [Ref. 17]. The high salt content of this high Cs-137 activity waste prevents much additional concentration of that waste. Therefore, it is not credible that the Cs-137 content assumed for the bounding hydrogen generation can be exceeded.
- The Corrosion Control Program [Ref. 4] establishes the requirements for the corrosion prevention of the waste tanks and equipment by monitoring the concentration of the corrosive species, including nitrite and nitrate, present in the supernate. The concentrations of these species are recorded in WCS Online [Ref. 17] after being validated and approved by the Data Integrity Review Team (DIRT) [Ref. 5]. Nitrite and nitrate act as hydrogen scavengers that serve to decrease the overall hydrogen production.
- An analysis of historical corrosion chemistry at high hydroxide concentrations has shown that a minimum NOeff of 1.55M is reasonable to use for flammability projections [Ref. 6]. This provides some conservatism into the evaporator bottoms hydrogen generation rate limit since the empirical NOeff value of 1.55M is greater than the NOeff of 1.0M used to derive the limit. In addition, a calculation based on supernate concentrations in the waste tanks combined with a 1 wt% sludge composition in the evaporator feed tank has shown all values to be below the evaporator bottoms hydrogen generation rate limit of 9.6E-6 ft^3/hr·gal [Ref. 7].
- The Sludge Carryover Minimization Program [Ref. 8] establishes the controls for the minimization of sludge solids carryover into the evaporator thus ensuring that the DSA assumptions are maintained.
- The Waste Acceptance Criteria [Ref. 9] for the Tank Farms verifies that influent waste streams will not cause the evaporator bottoms hydrogen generation rate to

be exceeded when the incoming waste is sent directly to an evaporator feed tank or when it is combined with other tank farm waste awaiting future processing (i.e., evaporation).

Implementation Requirements

- Due to the conservative assumptions (high Cs-137 content, low NO_{eff}, 1wt% sludge) used in the DSA to derive the bounding evaporator bottoms hydrogen generation rate, there are no implementation requirements and actions required to protect the assumed limit.

4.1.2 Radiolytic Hydrogen Generation Rate for Scale in 242-16H Evaporator

The bounding radiolytic hydrogen generation rate for the evaporator scale is 4.75E-5 ft^3/gal-hr [Ref. 1]. The production rate of hydrogen is proportional to the radiolytic heat load of the waste in the tank. Sr-90, Cs-137, Ce-144, Pu-238, Cm-244, Pu-239, and Am-241 are major contributors to the radiolytic heat load [Ref. 1].

Implementation Requirements and Actions

- Reference 24 established a conservative basis for the bounding hydrogen generation rate due to future scale buildup in the 242-16H Evaporator. By using high values for the concentration of radionuclides in the scale samples (i.e., the average value plus two relative standard deviations) and a low estimate of the volume of material in each sample (i.e., the average value minus two relative standard deviations), and assuming 0M NO_{eff} in the scale, the evaluation concluded that the hydrogen generation rate of 4.75E-05 ft^3/gal-hr is conservative for future scale formation in the 242-16H Evaporator. Therefore, there are no implementation requirements and actions required to protect the assumed limit.

4.2 NAS Scale Formation Rate

Typical high level waste contains large quantities of aluminum and small quantities of silicon, so relatively small changes in the silicon concentration result in significant changes in the expected formation rate of solids in the evaporators. Startup of Defense Waste Processing Facility (DWPF) Recycle stream introduced excess silicon into the waste tanks. When the high-silicon waste is used as evaporator feed, a mechanism exists to accumulate a hard scale composed of NAS. The scale decreases evaporator performance and presents a potential criticality safety concern due to the accumulation of fissile uranium with the NAS scale. Following observation of the NAS in the evaporator systems, the feed streams to the Tank Farms were directed such that the aluminum bearing feed (i.e. canyon waste or sludge batch decants) was processed via the 242-25H Evaporator System and the silicon bearing feed (i.e., DWPF recycle) was processed via the 242-16H Evaporator System. By segregating the high aluminum stream from the high silicon stream, NAS formation rate is controlled and monitored in the 242-16H system and prevented in 242-25H Evaporator System.

Preventing the formation of NAS will eliminate the criticality concern caused by the uranium presence with the NAS scale in the 242-25H **E**vaporator pot.

The calculations to determine the NAS formation rate for the Evaporator System identified in the DSA are defined below. The DSA, Section 5.5.4.2.25 describes the necessary program to prevent NAS scale formation in the 242-25H Evaporator. Implementation requirements and actions required for the 242-25H Evaporator System are also described below.

4.2.1 NAS Formation Rate Methodology

The methodology for calculating the NAS solid formation rate is based on the Gasteiger [Ref. 10] approach. First, the solubility product of NAS solids (K_{sp}) is calculated using Equation 1:

Eq. 1 $$K_{sp} = \frac{1.5 * 10^{-4} \times [\mathrm{OH}]^3}{[\mathrm{I}]^{1.6667}}$$

Then, the soluble silicon is calculated using Equation 2:

Eq. 2 $$\mathrm{Si}_{\mathrm{soluble}} = \frac{\mathrm{K_{sp}} \times 28{,}000\ {}^{\mathrm{mg}}/_{\mathrm{mol}}}{[\mathrm{Al}]}$$

Finally, Equation 3 estimates the amount of NAS that will precipitate after the 3x concentration by evaporation. This equation calculates the insoluble silicon concentration at a given concentration factor, normalizes this concentration to the starting volume, and converts to equivalent aluminosilicate quantity. Equation 3 calculates the mass of NAS produced by evaporating 1 liter of waste.

Eq. 3 $$\mathrm{mass}_{\mathrm{NAS}} = \left(\frac{\mathrm{Si}_{\mathrm{total}} - \mathrm{Si}_{\mathrm{soluble}}}{\mathrm{Si}_{\mathrm{total}}}\right) \times \mathrm{Si}_{\mathrm{start}} \times \frac{\mathrm{g\,NAS}}{0.16\,\mathrm{g\,Si}} \times \frac{\mathrm{g}}{1000\,\mathrm{mg}}$$

Where:
K_{sp}: NAS solubility product,
[I]: ionic strength (mol/L),
[OH]: hydroxide concentration (mol/L) of the combined contents (i.e., sending tank and evaporator tanks),
[Al]: aluminum concentration (mol/L) of the combined contents (i.e., sending tank and evaporator tanks),
Si_{start}: silicon concentration (mg/L) of the combined contents (i.e., sending tank and evaporator tanks),
Si_{total}: total Si concentration (mg/L), which is three times the Si_{start},
$Si_{soluble}$: concentration of soluble silicon (mg/L),
$mass_{NAS}$: amount of NAS (g/L) produced in the pot.

The calculated NAS formation rate will be used to compare with the historical maximum NAS formation rate for feed to the evaporator. Therefore, use of nominal values for [I], [OH], [Al], and [Si] are acceptable and does not need to include analytical uncertainty.

For simplification, the Na concentration is used as the ionic strength of the solution. Therefore, the concentration of carbonate, sulfate, oxalate and phosphate in the combined supernate shall be less than 0.5 M. In the event the concentration of these species is above or equal to 0.5 M, the engineering evaluation will address the impacts to the ionic strength accordingly.

The laboratory analysis for silicon concentration can be performed by either the filtration method or the acid strike method [Ref. 11]. For the filtration method, the analytical lab will report the total silicon concentration adjusting for any filter loss during the analysis [Ref. 12]. The Sampling Methodology document describes the method for sample retrieval and analysis [Ref. 13].

4.2.2 Implementation Requirements and Actions

The ERD Table G-4 compiles the list of waste tanks potentially containing high Si and low OH waste. Any transfers from the waste tanks containing DWPF recycle or similar waste to the 242-25H Evaporator System shall be pre-evaluated to prevent the formation of NAS in the evaporator system. The methodology to calculate the NAS formation rate is provided in Section 4.2.1. Changing the relationship of sodium, aluminum, silicon and hydroxide in the combined contents (i.e., the sending tank and the evaporator system tanks) will affect the rate of NAS formation. Waste tanks with low concentrations of sodium, aluminum, and silicon and high concentration of hydroxide will decrease the NAS formation rate. Waste tanks containing a large quantity of aluminum makes silicon the limiting reactant. A relatively small increase in silicon concentration will significantly increase the rate of NAS produced in the evaporator pot. Therefore, it can be discerned that as bulk waste is removed from the tanks, the concentrations of sodium, aluminum, and silicon will increase while the addition of water will decrease the hydroxide concentration. The potential for forming NAS in the evaporator pot if the material is processed through the 242-25H Evaporator System could exist [Ref. 23].

The following implementation requirements and actions are only applicable to the 242-25H Evaporator System.

1. Waste tanks containing DWPF recycle or similar waste shall be listed in the ERD Table G-4 (N-ESR-G-00001). Similar waste is defined as waste that contains high silicon and low hydroxide concentrations as DWPF recycle.

2. If DWPF recycle or a similar waste is transferred into a waste tank that does not contain DWPF recycle or a similar waste, the waste tank (other than the feed and drop tanks of 242-25H Evaporator) shall be added to the ERD Table G-4 [TSR AC 5.8.2.25.b].

3. A waste tank (other than the feed and drop tanks of the 242-25H Evaporator) shall be listed in the ERD Table G-4 as part of initiating bulk waste (i.e., sludge or salt) removal activities.

4. The DSA requires the silicon concentration and NAS formation rate to be determined every six months with a 25% extension allowance based on samples from the feed and

drop tanks. Samples shall be drawn from multiple tank elevations. In order to satisfy this requirement, the NAS baseline calculation [Ref. 14] is updated twice each year at six month intervals. To implement the program, the samples should be pulled no later than 60 days prior to the NAS baseline calculation due date. Samples pulled prior to six months before the due date cannot be used in the NAS baseline evaluation. Management signature for approval of the baseline calculation signifies completion of this requirement [Ref. 15]. If the baseline calculation has not been performed for the feed tank within the required frequency, then the evaporator shall be shut down immediately (secure feed pump and secure steam to tube bundle and lance) and not restarted until the silicon concentration and NAS formation rate has been determined and evaluated against criteria 6.1 and 6.2 below. If the baseline calculation has not been performed for the drop tank within the required frequency, then the affected evaporator drop tank waste shall not be recycled back to the feed tank until the silicon concentration and NAS formation rate has been determined and evaluated against criteria 6.1 and 6.2 below [TSR AC 5.8.2.25.c].

5. Prior to transferring the DWPF recycle or similar waste to the 242-25H Evaporator System (i.e., feed and drop tanks), the Evaluated Transfer Approval Form (ETAF) shall be performed to verify if an evaporator feed qualification evaluation with all compensatory measures established is completed and approved for the transfer [TSR SAC 5.8.2.25].

6. An evaporator feed qualification evaluation shall be performed against the following criteria prior to transferring the DWPF recycle or similar waste to the 242-25H Evaporator System (i.e., feed and drop tanks) [TSR SAC 5.8.2.25]. Analytical uncertainty does not need to be included in the evaporator feed qualification evaluation [Ref. 1].

6.1 The average concentration of silicon in the process stream transferred to the evaporator system shall be less than 120% of the historical maximum silicon concentration for feed to the evaporator. Prior to determining the historical maximum silicon concentration, it must be verified that scale formation has not occurred during the operating period. Sampling for silicon in the sending tank is not required. Silicon concentrations of the sending tank may be based on engineering evaluations and process knowledge based on previous samples and known additions [TSR AC 5.8.2.25.a.1].

6.2 The calculated NAS formation rate from the combined transfers and the evaporator tank waste shall be less than 110% of the historical maximum formation rate for feed to the evaporator. The methodology used to calculate the NAS formation rate is provided in Section 4.2.1 [TSR AC 5.8.2.25.a.2].

6.3 The free hydroxide of the transfer waste shall be greater than 1 mol/L for transfers directly into the evaporator feed tank [TSR AC 5.8.2.25.a.3].

If the transfer volumes are less than 10,000 gallons, the transfer wastes with free hydroxide concentrations less than or equal to 1 M that meet attributes 6.1 and 6.2 may be made into the evaporator feed tank if:

- feed to the evaporator is stopped prior to initiation of the transfer, and
- feed is not restarted until at least 24 hours after the transfer is complete.

6.4 The free hydroxide of the transfer waste shall be greater than 1 mol/L for transfers into the evaporator drop tank. If the free hydroxide concentration is less than or equal to 1 mol/l, the transfers shall not be approved unless the following requirements are met:

6.4.1 The hydroxide concentration in the combined contents (e.g., initial drop tank waste, sending tank waste, further evaporator bottoms received in the drop tank, and any other transfer receipts into the drop tank) must be greater than 1 M (based on calculation) prior to transfer to the feed tank [TSR AC 5.8.2.25.a.4.1].

6.4.2 Prior to receipt of a low hydroxide transfer, recycle transfers from the drop tank to the feed tank shall be stopped. Subsequent recycle transfers shall not be initiated until completion of the low hydroxide waste transfer and the conditions of attribute 6.4.3 are satisfied [TSR AC 5.8.2.25.a.4.2].

6.4.3 In addition to 6.4.1 and 6.4.2 above, at least one of the following three conditions must be met:

6.4.3.a Prior to receipt of a low hydroxide waste transfer, the drop tank shall have a waste level greater than or equal to 120 inches above the downcomer discharge and the drop tank hydroxide concentration shall be greater than or equal to 4 M [TSR AC 5.8.2.25.a.4.3.a].

6.4.3.b After receipt of a low hydroxide waste transfer and prior to the first subsequent recycle transfer from the drop tank to the feed tank, a supernate sample from the surface of the drop tank shall indicate greater than 1 M hydroxide concentration. The surface sample shall be pulled after receipt of the low hydroxide waste transfer and prior to the first subsequent recycle transfer from the drop tank to the feed tank. The sample is still considered valid in the case where the evaporator has operated (i.e., lifting the bottom from the pot and transferring them to the affected drop tank) between the time of the low hydroxide waste transfer receipt and the time the sample is drawn [TSR AC 5.8.2.25.a.4.3.b].

6.4.3.c After receipt of a low hydroxide waste transfer and prior to the first subsequent recycle transfer from the affected drop tank to the feed tank, the evaporator shall be operated for a sufficient duration to lift 100,000 gallons of evaporator bottoms to the drop tank [TSR AC 5.8.2.25.a.4.3.c].

6.5 The sending tank jet/pump suction shall be positioned to minimize the disturbance and entrainment of waste from within the unsettled transition layer above the solids/supernate interface, which may contain high concentrations of aluminum, silicon, iron, uranium and manganese. The evaporator feed qualification evaluation shall address the sending tank jet/pump suction elevation and the resulting impact of its disturbance of the sludge solids/supernate interface. Controls imposed on the sending tank jet/pump suction elevations to minimize the disturbance and entrainment of sludge

during waste transfers are provided in the Sludge Carryover Minimization Program [Ref. 8] [TSR AC 5.8.2.25.a.5].

7. If an intended or unintended transfer of DWPF recycle or similar waste into the 242-25H Evaporator System (i.e., feed or drop tank) that did not meet the requirements of criteria 6.1 through 6.5 is made, then the evaporator shall be immediately shutdown (secure feed pump and secure steam to tube bundle and lance). An engineering evaluation must be performed to evaluate the potential for scale formation in the evaporator and determine any corrective actions necessary is performed. The evaporator shall not be restarted until all the requirements documented in the engineering evaluation have been demonstrated to be met [TSR SAC 5.8.2.25.a.6].

8. The 242-25H Evaporator pot shall be inspected at least once every 2,160 hours (90 days) of evaporator operation. The pot may be inspected at least once every 4320 hours (180 days) of evaporator operation if a satisfactory evaporator pot siphon is performed every 720 hours (30 days) of evaporator operation. If a controlled siphon from the evaporator pot has a flowrate less than the established baseline flowrate (i.e., siphon flow rate obtained under clean pot conditions), then prior to subsequent evaporator operation a successful siphon of the evaporator must be performed. Evaporator operation is considered to be the amount of time steam is supplied to the tube bundle [TSR SAC 5.8.2.25.d.1 & d.2].

9. The results of the pot inspection shall be evaluated by an Evaporator Cognizant Engineer. If the inspection results indicate unacceptable accumulation of solids/scale, then waste feed to the evaporator shall be shutdown immediately (secure feed pump and secure steam to tube bundle and lance). Observation of normal salt encrustation during the pot inspection is not of concern for the purposes of the program [Ref. 1] [TSR SAC 5.8.2.25.d.3].

10. Waste tanks containing DWPF recycle or similar waste can be removed from the ERD Table G-4 if [Ref. 23].

- Tanks closed and backfilled with grout (e.g., Tanks 5, 6, 12, 16, 17, 18, 19, and 20), OR
- Tanks being de-inventoried (e.g., tanks entering heel removal phase) and the remaining contents in the waste tanks are demonstrating that:
  - Silicon concentration in the waste tank is below a bounding value to be determined to ensure all receipts are significantly below 120% of the historical limit of the 242-25H Evaporator System, AND
  - Calculated NAS formation rate from the combined contents (i.e., the remaining contents in the tank with any material transferred into the tank and the 242-25H Evaporator System) is less than or equal to 0 g/l to ensure the NAS formation rate for waste in the evaporator systems will not reach saturation and will remain in solution.

Concentrations of constituents used to calculate silicon and NAS concentrations shall be based on sample results.

11. An evaporator feed qualification evaluation shall be performed against the criteria listed in Item 6 for a waste tank (other than the 242-25H feed and drop tanks) in which bulk waste removal activities (i.e., salt dissolution or sludge removal) are performed prior to transferring the waste tank material to the 242-25H Evaporator System. Since the supernate composition in the 242-25H feed and drop tanks have been periodically analyzed and qualified, an evaporator feed qualification evaluation is not required for transferring a heel of dissolved salt left in the evaporator drop tank into the affected Evaporator System.

4.3 Evaporator Enrichment and Flammability Monitoring

A Nuclear Criticality Safety Evaluation [Ref. 16] (NCSE) has been performed to evaluate the formation of NAS scale containing sodium diuranate in the 242-16H **E**vaporator pot. This Program Description Document addresses the implementation of the programmatic requirements specified in the NCSE and, as such, shall be considered the 242-16H Evaporator Enrichment Monitoring. The 242-16H **E**vaporator pot flammability controls are also addressed.

Implementation Requirements and Actions

The following implementation requirements and actions are only applicable to the 242-16H Evaporator System.

1. The maximum subcritical equivalent U-235 (U-235 (eq)) enrichment for the 242-16H Evaporator System shall be 5.5 wt% under normal operations. The Pu content of the fissionable elements in the 2H supernate shall not exceed 2 wt% [Ref. 1]. This is accomplished by monitoring the influents into Tank Farm and into the 242-16H evaporator feed and drop tanks (Tanks 43 and 38, respectively). See the following steps for specific actions.

1.1 The U-235 (eq) enrichments of DWPF recycle shall be less than or equal to 5.5 wt%. Tank Farm waste tanks storing influent waste streams for future processing through the 242-16H **E**vaporator **S**ystem (Tank 22) shall be less than or equal to the target U-235 (eq) enrichment of 5.5 wt%. Waste streams with U-235 (eq) enrichment in excess of 5.5 wt% shall not be added to the 2H Evaporator System. Exceptions: Waste transfers from DB-7 sump to Tank 38 and from the 2H Evaporator sump to Tank 43 are exempted from this requirement [Ref. 1].

1.1.1 The Waste Acceptance Criteria [Ref. 9] Program requires that DWPF recycle U-235 (eq) enrichment be less than or equal to 5.5 wt%.

1.1.2 U-235 (eq) and equivalent uranium (U (eq)) are to be calculated per the formulas:

U-235 (eq) = U-235 + 1.4 x U-233 + 2.25 x (Pu-239 + Pu-241)

U (eq) = U + 2.25 x (Pu-239 + Pu-241)

$$\%\mathrm{U-235\ (eq)\ enrichment} = \frac{\mathrm{U-235\ (eq)}}{\mathrm{U(eq)}} \times 100\%$$

To account for any uncertainties, two relative standard deviations shall be added to each concentration in the numerator and average values shall be used for the denominator.

1.1.3 The Waste Acceptance Criteria [Ref. 9] Program requires that the plutonium content of the fissionable elements in the waste transfers into the 2H Evaporator System shall not exceed 2 wt%.

1.1.4 The wt% Pu content is to be calculated as follows:

$$\text{wt\% Pu} = \frac{\sum \text{Pu}}{\sum \text{Pu} + \sum \text{U}} * 100\%$$

where:

∑Pu: sum of Pu isotopic concentrations (e.g., Pu-239, Pu-241, etc…)

∑U: sum of U isotopic concentrations (e.g., U-235, U-238, etc…)

To account for any uncertainties, two relative standard deviations shall be added to each plutonium isotopic concentration in the numerator. For the denominator, average values shall be used. For those uranium isotopes whose actual concentrations are not reported, zero values will be assumed in the Pu calculation.

1.1.5 Prior to transfers of non-DWPF recycle into Tank 22, a pre-engineering evaluation shall be performed to determine the U-235 (eq) enrichment and Pu content of the transfer waste based on sample results of the individual waste stream making up the waste batch or the blended waste batch. The ETAF [Ref. 17] shall verify that the addition to Tank 22H has an U-235 (eq) enrichment of ≤ 5.5 wt% and plutonium content of the fissionable elements of ≤ 2 wt%.

1.1.6 Prior to transfers of waste other than recycle transfers (e.g., drop tank to feed tank) and Tank 22 containing DWPF recycle to the 2H Evaporator System, a pre-transfer evaluation shall be performed to determine the U-235 (eq) enrichment and Pu content of the transfer waste using sample results of the individual waste stream making up the waste batch or the blended waste batch. The ETAF [Ref. 17] shall verify that the transfer waste has an U-235 (eq) enrichment of ≤ 5.5 wt% and a plutonium content of the fissionable elements of ≤ 2 wt%.

1.1.7 Samples used for determination of U-235 (eq) enrichment and Pu content in Sections 1.15 and 1.16 shall be taken at a minimum two depths of the waste batch. Exception: For mixed tanks, one sample is sufficient to characterize the tank contents when performed in accordance with the Sampling Methodology document [Ref. 13]. Sample results (accounting for measurement uncertainty) shall be reviewed by DIRT for acceptability and consistency with past results and/or current process knowledge.

1.2 Routine sampling and associated analysis of supernate in Tank 38 and Tank 43 shall be performed to monitor the U-235 (eq) enrichment [Ref. 1].

1.2.1 Samples of supernate of Tanks 38 and 43 shall be pulled every 26 weeks. Samples shall be taken at a minimum of two supernate depths. In the case of an extended outage, the 26 week sampling requirement may be deferred, but the sampling and analysis shall be completed and the results shall be available prior to restarting the evaporator [Ref. 1]. The Sampling Methodology document describes the method for sample retrieval and analysis [Ref. 13]. The sample analysis results shall be reviewed and approved by DIRT for acceptability and consistency with past results and/or current process knowledge [Ref. 1]. Sample results shall be reported within 60 days of the sample pull date [Ref. 1]. If this requirement is not met, feed to the 242-16H Evaporator shall be secured until the results are reported. Approval of the enrichment results will be communicated via a numbered memorandum and/or Morning Report to appropriate facility

operations personnel and Shift Technical Engineers (STEs). The results of the enrichment samples will be updated in the Emergency Response Data (ERD) upon the next revision [Ref. 18].

1.2.2 If the sample analysis results are greater than 5.5 wt% U-235 (eq) enrichment or greater than 2.0 wt% Pu content, the feed to the 242-16H Evaporator shall be secured until a documented engineering evaluation demonstrates subcriticality [Ref. 1].

2. Waste transfer operations shall be monitored to ensure sludge solids are not disturbed in Tank 43 and inadvertent transfers into Tanks 38 or 43 are precluded [Ref. 1].

2.1 All influent waste streams into Tank 43 shall be positioned at greater than or equal to 36 inches above the settled sludge surface (e.g., side wall penetrations, downcomers, backflush valve, etc.) [Ref. 1].

2.1.1 This requirement is implemented through the Sludge Carryover Minimization Program [Ref. 8], transfer system design and backflush valve design.

2.2 The Tank 43 evaporator feed pump recycle discharge shall be greater than or equal to 24 inches above the settled sludge surface [Ref. 1].

2.2.1 This requirement is implemented through the Sludge Carryover Minimization Program [Ref. 8].

2.3 The Tank 43 feed pump suction shall be positioned at greater than or equal to 24 inches above the settled sludge surface [Ref. 1].

2.3.1 This requirement is implemented through the Sludge Carryover Minimization Program [Ref. 8].

2.4 If there is an indication that the separation distances above are not met (e.g., turbidity measurement, suspended solids in samples, error in specification on drawings) [Ref. 1].

2.4.1 The feed to the evaporator shall be secured, but waste may be received in Tank 43,

2.4.2 The feed to the evaporator shall not be restored until:

a) the minimum separation distance(s) is restored, and

b) the turbid zone of suspended solids is demonstrated to be less than or equal to 5.5 wt% U-235 (eq) enrichment and 2.0 wt% Pu content.

2.4.3 If the separation distances cannot be restored, or the turbid zone was determined to be greater than 5.5 wt% U-235 (eq) enrichment or 2.0 wt% Pu content, a nuclear criticality safety evaluation shall be performed prior to restoring feed to the evaporator.

2.5 The supernate level shall be maintained at greater than or equal to 36 inches above the sludge layer in Tank 43 [Ref. 1].

2.5.1 This requirement is implemented through the SW11.1-WTE, Section 7.2 procedure.

2.6 Tank 43 Flygt mixers shall be permanently disabled/de-energized [Ref. 1].

2.6.1 The Tank 43 Flygt mixers have been electrically disconnected. Much of the equipment that supports the use of the pumps has been removed. This is to ensure that the Flygt mixers cannot provide a source of mixing to the tank nor to the sludge [Ref. 16]

2.7 Tank 38 or Tank 43 is monitored during a transfer for transfer events per the Transfer Control Program [Refs. 1, 19],

2.7.1 The transfer paths shall be set using approved procedures.

2.7.2 The transfer paths shall be verified by a second operator prior to the transfer.

2.7.3 During the transfer the sending and receiving tank levels shall be checked every 30 minutes for the first two hours of the transfer.

2.7.4 Material balance shall be performed for transfers exceeding 15,000 gallons. The feed to the 2H Evaporator shall be secured if a transfer discrepancy exceeds 15,000 gallons.

2.7.5 Resumption of feed to the 2H Evaporator shall not begin until it is verified that the inadvertent transfer exceeding 15,000 gallons was not received in Tank 43 or Tank 38 or a documented engineering evaluation has been performed demonstrating that the evaporator will remain subcritical with the additional material.

2.8 All influent waste streams into Tank 38 shall be positioned at greater than or equal to 36 inches above the salt layer (e.g., side wall penetrations, downcomers, backflush valve, etc.) [Ref. 1].

3. 242-16H evaporator operation shall be monitored on a routine basis to assess scale buildup in the evaporator pot.

3.1 The evaporator pot shall be visually inspected at least 4,320 hours (180 days) of evaporator operation for the presence of scale [TSR SAC 5.8.2.26].

3.2 The results of the inspection shall be evaluated and used to determine the volume of accumulated scale in the pot and the remaining hours of operation without exceeding the TSR limit of 200 gallons of scale [Ref. 20]. The methodology for estimating scale volume shall be determined by Engineering. The evaporator operation is considered to be the amount of time steam is supplied to the tube bundle, excluding the time steam is supplied to the tube bundle during chemical cleaning [Ref. 1].

3.2.1 If the total volume of accumulated scale is determined to be greater than 200 gallons, waste feed to the 242-16H Evaporator shall be shut down immediately. The 242-16H Evaporator shall not be restarted until the scale volume is reduced below limits. [TSR SAC 5.8.2.26]

3.2.2 The 242-16H Evaporator Cognizant Engineer shall provide the next pot inspection due date and the remaining operation hours to Operation for updating into the Tank Farm Morning Report [Ref. 21].

3.2.3 The Tank Farm Morning Report will automatically update the remaining operation hours and the next pot inspection due date based on the number of hours the evaporator has operated from the last pot inspection.

4. The 242-16H Evaporator pot is visually inspected periodically based on operating history for the presence of scale. If the scale volume approaches the applicable limit defined in Reference 16, chemical cleaning is performed.

4.1 The maximum subcritical NAS deposit for the cleaning process shall be determined from Table 5.4.1-1 and 5.4.1-2 of Reference 16 based on the U-235 (eq) enrichment in the 2H Evaporator System and the maximum known U (eq) loading in the NAS deposit.

4.2 The evaporator shall be inspected periodically to ensure the maximum subcritical NAS deposit for the cleaning process is not exceeded. The estimate of the NAS deposit accumulation shall include measurement uncertainty [Ref. 1].

4.2.1 The maximum time to inspection can be determined based on the NAS upper range accumulation rate of 15 gallons/month and the maximum subcritical NAS deposit obtained in 4.1. Operations inspects for NAS deposit accumulation periodically at least once in the period between the evaporator start time and the maximum time to inspection. Note that the frequency of inspections is based on the evaporator operation hours.

4.3 Prior to introduction of a cleaning agent into the 242-16H Evaporator, two NAS deposit samples shall be taken and analyzed to determine the U-235 (eq) enrichment and the U (eq) loading [Ref. 1].

4.3.1 NAS deposit sample data shall be reviewed by DIRT for acceptability and consistency with past results and/or current process knowledge.

4.3.2 To account for analytical uncertainty, two relative standard deviations shall be added to each concentration.

$$U_x = U_{x,reported} + [2 \times (RSD/100) \times U_{x,reported}]$$

Where,

U_x is the concentration of the analyte in sample x after adjusting for analytical uncertainty (wt%)

$U_{x,reported}$ is the reported concentration of the analyte in sample x (wt%)

RSD is the relative standard deviation (%)

4.3.3 After adjusting for analytical uncertainty, the concentration of each analyte in the NAS deposit samples shall account for sampling uncertainty as follows [Ref. 25]:

$$U_{avg} = (U_1 + U_2) / 2$$

Where,

U_{avg} is the average of the values in each sample (wt%)

U_1 and U_2 are the concentrations of the analytes in each sample after adjusting for analytical uncertainty (wt%)

$$U_{max} = U_{avg} + 3.157 \times |U_1 - U_2|$$

Where,

U_{max} is the concentration of the analyte accounting for sampling uncertainty (wt%)

$|U_1 - U_2|$ is the absolute value of the difference between U_1 and U_2 (wt%)

4.3.4 For enrichment calculations, the equations from Step 1.1.2 shall be used. When determining the U-235 (eq) value in Step 1.1.2, the concentrations of each analyte shall account for analytical and sampling uncertainty as described in Steps 4.3.2 and 4.3.3. The value of U (eq) in Step 1.1.2, used in the denominator of the formula for U-235 (eq) enrichment, shall use average values (i.e., no uncertainty applied). Concentrations of analytes that are below detection limits are assumed to be at the detection limit for the calculation of the U-235 (eq) value (no sampling uncertainty is required). If the value appears in the U (eq) calculation, then the concentration is assumed to be zero. This method is used for conservatism.

4.3.5 Using the obtained NAS deposit U-235 (eq) enrichment and U (eq) loading, determine the maximum subcritical NAS deposit from Table 5.4.1-1 or 5.4.1-2 of Reference 16.

4.3.6 The estimated (accounting for the measurement uncertainty) subcritical NAS deposits (obtained in 4.1) shall be less than the maximum subcritical NAS deposit (obtained in 4.3.2).

4.3.7 If the estimated (accounting for the measurement uncertainty) subcritical NAS deposits exceed the maximum subcritical NAS deposits, a documented engineering evaluation shall be performed to demonstrate subcriticality.

4.4 An NCSA shall be written for each evaporator cleaning cycle to ensure the requirements of Reference 16 are met [Ref. 1].

4.5 Prior to introducing of a chemical cleaning agent to the 242-16H Evaporator, a 2H Evaporator Chemical Cleaning Management Checklist shall be developed. The checklist shall provide management a means to track and ensure all the prerequisite actions for entry into the 242-16H Evaporator Chemical Cleaning evolution are completed and to verify the system is ready to safely execute evaporator pot chemical cleaning. Additionally, the checklist shall track the required actions to return the 242-16H Evaporator to the design base configuration for normal system operation after the chemical cleaning is complete.

4.4 Interim Safety Basis Requirements

CSTF DSA Addendum U-DSA-H-00003 has been approved to cover operation of the 242-25H Evaporator with leak sites [Ref. 26]. The Evaporator Feed Qualification Program (Reference 1 Section 5.5.4.2.25) is supplemented to add the following requirement:

- **Prior to providing waste feed to the 242-25H Evaporator, ensure that the supernate nitrite concentration in the feed tank is greater than or equal to 0.0275 M [TSR SAC 5.8.2.25.e].**

The EFQ Program also ensures the composition of waste in the 242-25H feed tank complies with the hydrogen generation limits prior to transfer to the evaporator pot, and refers to Reference 1 Section 3.4.1.5.5. To account for the impact of thermolytic contribution has on hydrogen generation rate, the bounding hydrogen generation rate for 242-25H Evaporator Bottoms was updated to 1.5E-05 ft^3/gal-hr (at 25°C) for temperatures less than or equal to 100°C and 1.0E-03 ft^3/gal-hr for temperatures greater than 100°C [Ref. 28].

4.4.1 Supernate Nitrite Concentration

The required minimum supernate nitrite concentration in the waste feed to the 242-25H Evaporator pot is 0.0275 M (this value accounts for analytical uncertainty). To protect the nitrite concentration in the pot during flushing evolutions, a value of 0.281 M was chosen. The value is calculated assuming one volume flush of the evaporator pot and the following conservative inputs: (1) the evaporator pot heel

volume of 1,100 gallons, which is based on operating experiences; (2) the pot maximum operating volume of 11,250 gallons [Ref. 1].

$$\frac{0.0275\ \mathrm{M\ NO_2} * 11{,}250\ \mathrm{gals}}{1{,}100\ \mathrm{gals}} \sim 0.281\ \mathrm{M\ NO_2}$$

The minimum supernate nitrite concentration is required to effectively eliminate the catalytic hydrogen generation. Although not performed frequently, there are instances when additional flushing may be required. As the number of volume flush increases, the remaining radiological inventory in the evaporator pot as well as the concentration of the catalysts (e.g., rhodium (Rh), ruthenium (Ru)) decreases, which in turn reduces the hydrogen generation rate. Therefore, the 0.281 M value is also applicable to more than one volume flush of the evaporator pot.

The downcomer and feed pump in Tank 32 are located asymmetrically. A Computational Fluid Dynamics analysis of Tank 32 shows that liquid entering through the tank downcomer plunges through the supernate surface and flows downward. The fluid then flows outward in all directions until it reaches the tank walls. After that, it flows up the wall and along the supernate surface until it is entrained back downward toward the bottom of the tank. As a result, large recirculation regions are formed that essentially mix the tank supernate [Ref. 29]. The 1.63 M nitrite result of the surface sample taken from Tank 32 on 9/11/14 following the receipt of ~290,000 gallons of Tank 26 dilute supernate with 0.316 M nitrite on 9/5/14 and the 1.65 M nitrite predicted from WCS using material balance equation support the modeling (Refs. 30, 31). Therefore, no residence time is required for Tank 32 supernate when the tank resultant supernate nitrite concentration is re-established (i.e., greater than or equal to 0.281 M).

4.4.1.1 Implementation Requirements and Actions

1. **Liquid additions (e.g., waste transfers, water additions) to the 242-25H Evaporator System (i.e., evaporator feed tank and/or drop tanks) shall be pre-evaluated to determine the resultant nitrite concentration of the affected waste tank using WCS or an engineering evaluation.**
   - **If the nitrite concentration of the affected waste tank results in greater than or equal to 0.281 M, then liquid addition to the affected waste tank may be performed.**
   - **If the nitrite concentration of the affected waste tank results in less than 0.0275 M, then liquid addition to the affected waste tank shall not be performed [TSR SAC 5.8.2.25.e].**
   - **If the nitrite concentration of the affected waste tank (242-25H evaporator feed tank (Tank 32)) results in greater than or equal to 0.0275 M but less than 0.281 M, then the addition may be made into the feed tank if:**
     - **approved by the Facility Manager,**

- **feed to the evaporator pot is stopped prior to initiation of the addition, and**
- **feed to the evaporator pot is not restarted until the minimum nitrite concentration of 0.281 M in the feed tank supernate is re-established.**

- **If the nitrite concentration of the affected waste tank (242-25H evaporator drop tanks) results in greater than or equal to 0.0275 M but less than 0.281 M, then the addition may be made into the affected drop tank if:**
  - **approved by the Facility Manager and**
  - **recycle transfer from the affected drop tank to the feed tank is stopped prior to initiation of the addition.**

2. **Evaporator operation manual shall address the requirement to verify the supernate nitrite concentration in the feed tank is greater than or equal to 0.281 M prior to sending waste feed to the 242-25H Evaporator Pot.**

3. **Surface sample results imposed by the Corrosion Control Program may be used in determination of the receipt tank nitrite concentration following liquid additions. For waste tanks containing stratified supernate, alternate variable depth sample results may be used in the calculations on a case-by-case basis.**

4. **If the 242-25H evaporator feed tank undergoes bulk saltcake dissolution, the supernate nitrite concentration in the feed tank shall be verified to be greater than or equal to 0.281 M via sampling prior to sending the supernate to the 242-25H Evaporator Pot. Samples shall be taken at a minimum two depths of the supernate: (1) the surface of the supernate layer; (2) the bottom half of the supernate layer.**

4.4.2 Hydrogen Generation Rate for 242-25H Evaporator Bottoms

The bounding hydrogen generation rates for 242-25H Evaporator Bottoms consider both radiolytic and thermolytic contribution to Lower Flammability Limit. The contribution associated with radiolytic hydrogen generation was calculated according to the methodology shown in Reference 22. The contribution associated with thermolytic generation was evaluated and reasonable values were accounted for based on the limited simulant and real waste data [Ref. 27].

The 1.5E-05 ft^3/gal-hr (at 25°C) value is based on a sludge-bearing stream used as the bounding sludge slurry limit; however, supernate with very low wt% insoluble solids (i.e., << 1 wt%) is typically fed to the evaporator. The highest volumetric hydrogen generation rate due to radiolysis seen in Tank Farm waste tanks was 2.10E-06 ft^3/gal-hr (Tank 22). The thermolytic testing conducted on simulated and actual tank waste by the Savannah River National Laboratory (SRNL) at 100°C showed that the hydrogen generation rates due to thermolysis were less than 4.0E-

06 ft^3/gal-hr. Adding this value to the highest volumetric hydrogen generation rate seen in Tank Farm waste tanks would reasonably account for the thermolytic contribution to total hydrogen generation rate and still be well below the bounding hydrogen generation rates for 242-25H Evaporator Bottoms for temperatures less than or equal to 100°C [Ref. 28].

The high temperatures the 242-25H Evaporator typically operates at are in the 145-155°C range. Reference 28 plots the thermolytic hydrogen generation rate data available from the SRNL report up to 140°C and extend the trend line to 160°C to show what the hydrogen generation rate could be at normal operating temperatures. The thermolytic hydrogen generation rate could reasonably be estimated to be in the range of 10^{-4} ft^3/gal-hr. The highest volumetric hydrogen generation rate for an individual Tank Farm waste tank due to radiolysis is 2.10E-06 ft^3/gal-hr (Tank 22). The 1.0E-03 ft^3/gal-hr value was chosen as a reasonably conservative value that will bound the total hydrogen generation rate accounting for both radiolytic and thermolytic hydrogen generation mechanisms for temperatures greater than 100°C.

Given the degree of safety margin built into each of the bounding hydrogen generation rates for the 242-25H Evaporator Bottoms, there are no implementation actions required to protect the bounding values.

5.0 DEVIATIONS

Proposed deviations from the requirements as described by this PDD shall be evaluated as deemed appropriate. The proposed deviation shall be reviewed and approved by the Tank Farm Program Review Committee (PRC).

6.0 REFERENCES

1. WSRC-SA-2002-00007, Concentration, Storage, and Transfer Facilities Documented Safety Analysis.
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3. Deleted.
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12. X-CLC-G-00020, Rev. 0, Evaluation of Tank 6F Transfer into the 2F System and Tanks 35H and 42H into the 3H System, C. I. Aponte, August 30, 2002.
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21. http://pceweb.srs.gov/emr, Electronic Morning Report.
22. WSRC-TR-2003-00087, CSTF Flammability Control Program.
23. SRR-TR-2009-00001, Rev. 0. Evaluation of Tanks Containing DWPF Recycle or Similar Waste as Documented in the Emergency Response Data (ERD) Report, J. R. Vitali, March 2010.
24. HLW-STE-2001-00164, Determination of Bounding Hydrogen Generation Rate for Future 242-16H Sodium Aluminosilicate Scale, Rev. 0, C. S. Boley, April 16, 2001.
25. SRNL-TR-2018-00125, Rev. 0, Accounting for Sampling Variation of 2H-Evaporator Scale Samples, May 15, 2018, T. B. Edwards.
26. **U-DSA-H-00003, Rev. 0, Concentration, Storage, and Transfer Facilities Documented Safety Analysis Addendum: Operation of the 242-25H Evaporator with Leak Sites, April 2018.**
27. **SRNL-STI-2017-00611, Rev. 0, Investigation of Thermolytic Hydrogen Generation Rate of Tank Farm Simulated and Actual Waste, C. J. Martino, et al., November 2017.**
28. **CST-I-PR-0033, Rev. 1, Hydrogen Generation Rate for Evaporator Bottoms and 242-16H Evaporator Scale.**
29. **SRNL-TR-2008-00324, Rev. 0, Tank 32 Evaporator Feed Pump Transfer Analysis, D. A. Tamburello, et at., January 2009.**

30. F/H Area Laboratory Information Management System (LIMS) Database # 200661581 taken on 9/11/14 (Tank 32).
31. CAHarvest\LWO\WasteCharacterization\WCS 1.5_v012.6 under PostXfer Eval.

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Document Number: WSRC-TR-2003-00055 Revision: 13

Document Title: CSTF Evaporator Feed Qualification Program

The following checklist is required to be completed and attached to the document under review in compliance with Manual E7 and S4 procedures. This list should not be considered all inclusive. Add any additional notes or comments to the end of the checklist.

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	VERSION / FORMAT		
1	If revising an existing document, are you starting with the latest, approved version of the document obtained from SmartPlant Foundation (SPF) or DCR?	Yes	
2	Are all OSR or SPF forms properly and completely filled out and is the current approved version of the form used?	Yes	
3	Does the document format include all of the sections as described in manual E7 and S4 procedures (2.31A ,3.60, etc.)?	Yes	
4	Are all of the pages properly labeled with Document Number, Revision Number, and Sequential Page/Sheet Number?	Yes	
5	Are the Subject and Purpose clearly stated and do they meet the end-users needs?	Yes	
	REFERENCES		
6	Are all References properly documented within the document and can they be easily verified within Document Control, on-line, or within the library, etc.? If reference documents are not readily available, are they attached?	Yes	
7	Have the correct design bases documents been identified (e.g., Codes, Standards, DOE Orders, SRR Requirements, Regulatory Requirements, DSA)?	Yes	
	OPEN ITEMS / INPUT		
8	If data is transferred from other documents, calculations or sources, is this data correct and applicable?	N/A	
9	Are all inputs found in the body of the document or calculation individually listed and if the document is a calculation, numbered in the Inputs section?	N/A	
10	Is there a reference/source for each input?	N/A	
11	Do the identified references/sources fully support the inputs and does the data meet appropriate quality assurance requirements?	N/A	
12	Have the correct operational and functional requirements of the facility been properly considered?	N/A	

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	OPEN ITEMS / INPUT – continued		
13	Have appropriate operational modes and worse case scenarios been considered?	N/A	
14	Are all assumptions used to support the document individually listed and numbered in the Assumptions section?	N/A	
15	Is there a justification written for each assumption that includes a technical basis?	N/A	
16	Do the justifications adequately support the assumptions?	N/A	
17	If the document is a calculation and there are Open Items, has the calculation been statused as preliminary? Note: A Confirmed calculation cannot have Open Items.	N/A	
18	If the document is a preliminary calculation, have actions required to change the status from "preliminary" to "confirmed" been listed as "open items"?	N/A	
19	If the document has open items, is there a method identified to track them? List tracking numbers in Comments (STAR, POD item number, etc.).	N/A	
	ANALYTICAL METHODS AND COMPUTATIONS		
20	Are the analytical methods and computations clearly spelled out step-by-step?	N/A	
21	Is the analytical approach in use clearly described with justification along with alternative methods?	N/A	
22	Is the methodology consistent with the purpose and objective?	N/A	
23	Are mathematical derivations correct, including dimensional consistency of results?	N/A	
24	Have calculations been checked for errors as applicable per E7-2.31A, Sections 5.3.2.5 and 5.5.1? Where a calculation has multiple iterations of the same computation with numerous input and output values, the Verifier/Checker may select a representative sample of the total input and output values for review.	N/A	
25	Were the analysis inputs correctly incorporated into the analysis and are the outputs reasonable compared to the inputs?	N/A	
26	Is the Summary of Conclusion clearly stated? Does it meet the end-user's needs? Clearly state if results meet/do not meet the Objectives of the analysis?	N/A	
27	Are the numeric values consistent with the appropriate accuracy (significant figures) of the analysis?	N/A	
28	Are safety margins consistent with good engineering practice?	N/A	

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	SOFTWARE		
29	Is software (including spreadsheets) used? If NO, then "N/A" this section.	N/A	
30	Have computer software programs used for calculations been evaluated and properly classified for this activity using OSR form 19-337 (SWCD), per 1Q QAP 20-1 and E7-2.25? Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38. B) The SWCD (software classification document) form is a site-wide application in Lotus Notes.	N/A	
31	Is computer software used for the analysis being controlled per E7-2.31A, Section 5?	N/A	
32	Were appropriate analysis methods and computer methods used?	N/A	
33	If a computer program or model is used in the calculation, is it used within the range of validity, or is use outside the range of established validity justified?	N/A	
34	Was the software program used within any restriction, criteria or test frequency requirements in the Software Quality Assurance Plan? (SQAP) (e.g., computer operating system/platform criteria, software within testing frequency).	N/A	
35	Is the software used noted on the Calculation cover sheet and referenced appropriately in the calculation?	N/A	
36	If the calculation supports the DSA, is the software and version used on the SSIL (Safety Software Inventory List) when required? Provide explanation in Comments. Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38 B) The SSIL is updated on an annual basis so recently approved SQAPs may not be added to the SSIL until the next annual update.	N/A	
37	Are the equations shown in the calculation, including example functions where Excel spreadsheets or MathCad is used?	N/A	
38	If using general-purpose commercially available software as described in E7-2.31A, Section 5.5.1, then answer YES and describe checking method (5.5.1.2.C 1, 2, or 3) in Comments	N/A	
39	Have computer program error reports been checked for potential effect on the analysis?	N/A	

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

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	RESULTS / CONCLUSIONS		
40	Are the results of the document consistent with the input and assumptions?	N/A	
41	Do the results of the document affect any other technical documents?	N/A	
42	Do the results substantiate the conclusion?	N/A	
	APPROVALS		
43	Does the document identify the method of verification, if applicable, and does it have a signature block for the verifier/checker?	Yes	

Checker: J. R. Jacobs / John R Jacobs Jr Date: 5/31/18
Print Signature

Item No. Cont.	Comment Continuation
N/A	N/A

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Items 44-56 are only to be completed when Verification by Document Review is being performed. The verifier assures the technical accuracy of the document by performing administrative and mathematical checks as appropriate, and by evaluating the document against the following questions:

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44	Were the inputs correctly selected and identified?	N/A	
45	Are the assumptions made in the performance of the design or analytical activity adequately described and reasonable?	N/A	
46	When necessary, are the assumptions identified for subsequent re-verification when the detailed design activities are completed?	N/A	
47	Were appropriate design or analytical methods and computer programs used?	N/A	
48	Were the design or analytical inputs correctly incorporated into the design, analysis or evaluation?	N/A	
49	Have engineering actions required to support risk handling strategies been verified?	N/A	
50	Is the design output reasonable compared to the design or analytical inputs?	N/A	
51	Are the necessary design inputs for interfacing organizations specified in the design documents or in supporting procedures or instructions?	N/A	
52	Have suitable materials, parts, processes, and inspection and testing criteria been specified?	N/A	
53	Have existing and potential workplace hazards been identified, evaluated, and controls incorporated for the risk to worker injury or illness?	N/A	
54	Was a review conducted to confirm that there are no interferences with other ongoing or planned modifications?	N/A	
55	Have engineering judgments been identified, technically justified, and supported?	N/A	
56	Have design optimization strategies been considered / met (e.g., appropriate tailoring of requirements, design attributes, and operating strategies)?	N/A	

Verifier: J. R. Jacobs / John R Jacobs Jr Date: 5/31/18

Print Signature

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Item No. Cont.	Comment Continuation
N/A	N/A

CSTF Flammability Control Program

Program Description Document

PREPARED BY:

11/7/19

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11/12/19

J. N. Everett, Fire Protection Engineering Manager / Signature — Date

11/13/19

B. A. McKibbin, Program Review Committee Chairman / Signature — Date

11/14/19

D. C. Bumgardner, Tank Farm / ETP Facility Manager / Signature — Date

12-3-19

J. E. Occhipinti, Tank Farm Facility Engineering Manager / Signature — Date

Summary of Revisions

	Revisions 1-19	See Revision 23 for Summary
	Revisions 20-26	See Revision 26 for Summary
6/2016	Rev. 27	Total rewrite, no revision bars included
10/2016	Rev. 28	Section 4.1.2.3 – Clarified initial hydrogen concentration for spontaneous time to LFL Section 4.1.3.1 Variable H'_{EQ} Calculation – Clarified H'_{eq} is compared with 2.5% of the LFL_T in lieu of 2.5% of the LFL_{25C} Section 4.2.1.2.1 Clarified Seismic Quiescent Time determination when y_0(Seismic) < LFL_{OC} Section 4.3.1.2 Clarified verification of 2.5% of the LFL_{25C} prior to starting the prime mover Section 4.3.2.2 Variable H_{mix} Calculation – Revised wording to match DSA Updated References
11/2016	Rev. 29	Section 2.0 – Recognized Tank 12 as radiological facility Section 3.0 – Recognized continuous purge ventilation for Very Slow Generation Tanks is sufficient to account for dissolved hydrogen release from steam jetted transfers. Clarified the criteria to consider sludge as slurried sludge. Section 4.3.1 – Modified requirement associated with applicability of Free Supernate Removal Hydrogen Release Rate Limits – changed 36 hours to 48 hours Section 4.4 – Removed Tank 12 from waste tanks under Tank Fill Limits Program
9/2017	Rev. 30	Section 1.0 – Added other Safety Basis controls defined in WSRC-IM-94-10 Section 3.0 Section 4.0 – Added wording to acknowledge the Interim Safety Basis requirements supersede the ones in the DSA and TSR Added Section 4.8 - Added ESS compensatory measures 2.2.1, 2.2.6, 2.2.8, 2.2.9 and implementation actions Updated References
11/2017	Rev. 31	Section 4.3 – Corrected typographical errors on pages 86 thru 88 Section 4.3.2.2 – Revised wording on page 105 to match DSA Section 3.4.1.5.3.6 Section 4.8 – Added ESS compensatory measure 2.2.18 and associated implementation actions to implement U-ESS-G-00007, Rev. 1 Updated References

2/2018	Rev. 32	Section 4.2.3 – Added reference for mixing efficiency used in vapor space turnovers calculation Section 4.3.2 – Removed 242-16F evaporator from service Update References
5/2019	Rev. 33	Section 3.0 – Added terminology for Dissolution Water Skid System and waste tank mixing devices Section 4.1.2.2.1 – Updated Tank 50 maximum radiolytic hydrogen generation rate Section 4.2.1.1 – Clarified Quiescent Time Program still applicable to those tanks that have inter-mixed waste layers. Recognized SBP operation can create slurried sludge from settled sludge. Section 4.2.4 – Added items 13 to clarify SBPs to not be credited for any Quiescent Times Section 4.3 – Added SBP Operation Program to minimize sludge entrainment during SBP operation. Section 4.3.2.1 – Inserted a paragraph to discuss how to treat inter-mixed waste layers in GRM evaluation Section 4.3.2.2 – Updated variable V_{solids} calculation Section 4.3.2.3 – Revised to enable saltcake dissolution with mixing eductors and waste tank mixing devices in Gas Release Mode Section 4.3.2.4 – Added 2nd person verification of mixing eductor turntable operation Section 4.4 – Updated Tank Fill Limits Section 4.7 – Added temperatures the compressor oils evaluated. Section 9.0 – Updated references
11/2019	**Rev. 34**	**Section 3.0 – Updated definition for bulk saltcake layer, free supernate removal, saltcake interstitial liquid removal and saltcake well mining** **Section 4.2.1.1 – Added Reference 61** **Section 4.3 – Clarified Gas Release Program attribute applicability (including exclusions for some process transitions)** **Section 4.3.1.2 – Added action 8 to address unintended interstitial liquid removal during a free supernate removal** **Section 4.3.2 – Updated insignificant hydrogen release activities** **Section 4.3.2.1 – Recognized saltcake interstitial liquid removal using transfer jets without requiring enter GRM and added Reference 61** **Section 4.3.2.2 – Recognized vapor space volume using actual waste contents/inventory and clarified bulk saltcake dissolution with supernate coverage** **Section 4.3.2.4 – Updated action 13, added actions 15 thru 18** **Section 9.0 – Updated references**

LIST OF ACRONYMS

AC	Administrative Control
CLFL	Composite Lower Flammability Limit
CSMP	Commercial Submersible Mixer Pump
CSTF	Concentration, Storage, and Transfer Facility
DOE	Department of Energy
DSA	Documented Safety Analysis
DWS	Dissolution Water Skid
ERD	High Level Waste Emergency Response Data and Waste Tank Data
ESP	Extended Sludge Processing
ESS	Evaluation of the Safety of the Situation
GRM	Gas Release Mode
HLLCP	High Liquid Level Conductivity Probe
ISB	Interim Safety Basis
JCO	Justification for Continued Operation
LFL	Lower Flammability Limit
MCU	Modular Caustic Side Solvent Extraction Unit
NFPA	National Fire Protection Association
OA	Oxalic Acid
PDD	Program Description Document
PISA	Potential Inadequacy in the Safety Analysis
SAC	Specific Administrative Control
SAV	Safety Analysis Value
SCDHEC	South Carolina Department of Health and Environmental Control
SCFM	Standard Cubic Feet per Minute
SBP	Submersible Blender Pump
SMP	Submersible Mixer Pump
S/RID	Standards/Requirements Identification Document
STP	Standard Temperature and Pressure
TSR	Technical Safety Requirements

WCS	Waste Characterization System

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1.0 PURPOSE

The purpose of this Program Description Document (PDD) is to provide guidance to Engineering personnel for implementing controls contained in the Documented Safety Analysis (DSA), Technical Safety Requirements (TSR) Administrative Controls, or other Interim Safety Basis (ISB) documents defined by WSRC-IM-94-10 Section 3.0 (e.g., Justification for Continued Operation (JCO), Potential Inadequacy in the Safety Analysis (PISA), and Evaluation of the Safety of the Situation (ESS)). This document is not a Safety Basis Document.

This PDD describes the implementation plan for the Concentration, Storage, and Transfer Facilities (CSTF) Flammability Control Program, including the following ancillary programs provided for by the CSTF DSA [Ref. 1]:

Waste Tank Quiescent Time Program (SAC),

Gas Release Program (SAC),

Tank Fill Limits Program (SAC), and

Oil Control Program (AC)

Additional controls deemed necessary by program management are also described, such as F-ESR-H-00140, "Flammability Requirements and Controls of LWDP Waste Storage Tanks." [Ref. 35]

This PDD provides background information and describes attributes of the Flammability Control Program in sufficient detail such that procedures implementing flammability control can be developed.

2.0 SCOPE

The safety function of the CSTF Flammability Control Program is to protect the anticipated times to reach the Lower Flammability Limit (LFL) in individual waste tanks.

Tank 48 is outside the scope of the Flammability Control Program; flammable vapor requirements for Tank 48 are contained in Chapter 18 of the DSA. Tanks reclassified as a radiological facility (e.g., Tanks 5, 6, 12, 16 thru 20) are excluded from the Flammability Control Program requirements of the DSA and TSR. This PDD does not address these tanks any further.

Waste Tanks in Closure Mode (see Section 3.0) are excluded from the Flammability Control Program requirements of the DSA and TSR after the flammability-related Mode entry prerequisites are met [Ref. 1], however separate requirements (i.e., NFPA 69) for waste tanks in Closure Mode are outlined in this PDD. The prerequisites for entering the Closure Mode are described in this PDD.

Waste Tanks in Acidic Chemical Cleaning Mode (see Section 3.0) are excluded from the Flammability Control Program with the exception of tracking the waste tank flammability status

(i.e., Chemical Cleaning) and the emergency response priority (i.e., Priority 2) in the High Level Waste Emergency Response Data and Waste Tank Data (ERD) [Ref. 1].

3.0 TERMINOLOGY AND INPUTS

- LFL: Lower Flammability Limit – the minimum concentration of fuel (i.e. hydrogen, Isopar® L, and/or trace organics) in air at a given temperature and pressure such that combustion will occur if an ignition source is present. LFL refers generically to a flammable condition (i.e., LFL_{OC} or CLFL).

- LFL_{25C}: LFL of hydrogen gas at 25°C – 4.0% by volume [Ref. 1].

- LFL_T: Temperature corrected LFL for hydrogen.

- CLFL: Composite LFL – This represents the point at which the vapor space is flammable due to a combination of combustible vapors. In the case of Tank 50, this includes Isopar® L and trace organics.

- LFL_{OC}: Temperature and organic corrected LFL for hydrogen – Hydrogen concentration at LFL, including contribution from trace organics for all waste tanks other than Tank 50. For Tank 50, LFL_{OC} represents the hydrogen concentration at CLFL, including the contributions from both trace organics and Isopar® L (i.e. LFL_{OC} = 43.8% of the LFL for hydrogen at 43ºC [Ref. 24]).

- [NO_{eff}]: Sum of nitrate concentration and one-half nitrite concentration.

- Organics: For the purpose of flammability calculations, organics is used to describe any flammable vapor other than hydrogen that may contribute to the LFL (CLFL for Tank 50) [Ref. 1].

- Isopar® L: An organic solvent used in the treatment of radioactive waste in the Modular Caustic Side Solvent Extraction Unit (MCU) and may be present in Tank 50 due to potential carryover from MCU transfers. Isopar® L is an isoparaffin diluent which is a mixture of branched chain hydrocarbons, designated Isopar® L by the vendor. Although the solvent used in the MCU contains other organics, Isopar® L is the only MCU organic of analytical concern on flammable vapor generation and energy contribution to an explosion. The masses and vapor pressures of the other MCU solvent organic components are small enough to discount [Ref. 1].

- Sludge: Insoluble metal oxide/hydroxide compounds.

- Supernate: An aqueous solution containing dissolved sodium salts.

- Saltcake: A solids phase of dissolved sodium salts as a result of evaporation process.

- Hydrogen: Hydrogen (H_2) is the primary flammable gas of concern in the CSTF. The primary source of hydrogen is the radiolytic decomposition of water except during Acidic Chemical Cleaning of Type I/II Waste Tanks where hydrogen generation from corrosion of carbon steel is an additional source.

- Dissolved hydrogen: Hydrogen gas that is retained in the supernate [Ref. 1].

- Trapped hydrogen gas: Hydrogen gas that is retained in sludge or saltcake [Ref. 1].

- Saltcake or Sludge Soundings: Saltcake/sludge soundings, also known as steel tape saltcake/sludge soundings, consist of placing a manual tape with a metal wafer (or spike) at one end through the tank riser to measure the saltcake/sludge level. As the metal wafer (or spike) touches the saltcake/sludge, an average from multiple readings is taken, and the saltcake/sludge level is determined [Ref. 1].

- Turbidity Meters: Turbidity meters are portable instruments that may be used to determine the suspended sludge level via clarified supernate in the waste tanks. A turbidity meter consists of a battery, an ohmmeter, a photoresistor, and a light source. The turbidity meter measures sludge level by using light resistance to determine the amount of suspended solids in the solution. Sludge has a larger amount of suspended solids than supernate, so as the meter passes sludge/supernate interface, the amount of light that passes through the solution will decrease. The photoresistor detects the amount of light passing through a solution and provides an output that is measured on the ohmmeter [Ref. 1].

- Supernate Coverage: A layer of liquid (i.e., free supernate) which covers the bulk saltcake layer in a waste tank. This layer can range in depth from many feet of liquid to as little as an inch of liquid covering the saltcake, so long as only small saltcake peaks (height and base measures in inches, not feet) and salt on cooling coils are visible above the liquid surface. These small saltcake volumes above the liquid layer are acceptable because: 1) they release an insignificant volume of hydrogen as the interstitial liquid drains from the exposed saltcake and 2) they would release an insignificant volume of hydrogen if dissolved by an influent liquid [Ref. 41].

- Concentrated Supernate: Supernate which has an average bulk concentration greater than or equal to 9.6M Na OR has an average bulk density of greater than or equal to 1.45 g/mL. The saturation limits are indicative of general chemical tendencies, and not finite thresholds above which abrupt changes are expected. Thus, use of nominal values is acceptable and does not need to include analytical uncertainty [Ref. 1].

- Dilute Supernate: Any supernate which does NOT meet the above criteria for Concentrated Supernate [Ref. 1].

- Mixing Eductor: Mixing eductors (e.g., Low Volume Mixing Jets (LVMJs)) are submerged in the tank liquid near the saltcake layer. Mixing eductors are designed to promote saltcake dissolution via mixing. This is accomplished by discharging the water added through a

nozzle, entraining the liquid above the waste tank bulk saltcake layer through an eductor assembly at a ratio of 4 gallons of the waste tank liquid to 1 gallon of water added [Ref. 41].

- Dissolution Water Skid System: The in-tank components (e.g., eductors, piping) of the system are inserted through the tank risers. These components extend near the saltcake layer and provide uniform mixing of the free liquid during water addition. System components (e.g., water skid, supply tanks) are arranged to the side of the tank top depending on the available space near the location of the risers used for eductor insertion. The system uses well water to feed the supply tanks.

- Waste Tank Mixing Devices: The term "waste tank mixing devices" is used to describe any of the following: slurry pumps (any type), CSMPs, SBPs, or SMPs. The waste tank mixing devices are used to agitate the sludge. They may also be used to mix liquid within a waste tank to perform saltcake dissolution.

- Bulk Saltcake Layer: When supernate is present in a waste tank above saltcake, the bulk saltcake layer is the saltcake level in the tank as determined by measurement or engineering evaluation. When supernate coverage is being removed from a waste tank containing saltcake, the bulk saltcake layer is the level within a waste tank where supernate coverage is at its minimum; further liquid removal will uncover sufficient saltcake requiring consideration as interstitial liquid removal (e.g., uncovered salt peaks' height and base measurement transitions from inches to feet)**. Saltcake mounds located within a 20 ft radius from the center of the evaporator concentrate receipt riser in Tank 30, Tank 37, and Tank 38 are excluded from consideration as part of the bulk saltcake layer** [Ref. 1].

  Tanks 30, 37, and 38 are the only waste tanks that may be used as evaporator concentrate receipt tanks. Other waste tanks may be used to receive evaporator concentrate; however, they may not utilize the exclusion of saltcake mounds under evaporator concentrate receipt risers from consideration as part of the bulk saltcake layer.

- Sludge Agitation: A process of mixing sludge (excluding insignificant sludge agitation activities in Section 4.3.2) using waste tank mixing devices [Ref. 1].

- Free Supernate Removal: Free supernate removal is the process of removing liquid from above the solids layers (i.e., saltcake, sludge) in a waste tank. For activities involv**ed with** free supernate removal over saltcake (including pumping**/jetting** liquid from **below** the saltcake **surface**), the activity is considered free supernate removal provided the bulk saltcake layer has supernate coverage [Ref. 1].

- Bulk Saltcake Dissolution: Bulk saltcake dissolution is the process of dissolving saltcake (excluding insignificant bulk saltcake dissolution activities in Section 4.3.2) by adding liquid to a waste tank and/or mixing liquid within a waste tank (via waste tank mixing devices, mixing eductor, or waste tank recirculation transfer pumps associated with waste tank recirculation) [Ref. 1].

- Saltcake Interstitial Liquid Removal: Saltcake interstitial liquid removal is the process of removing interstitial liquid from bulk saltcake (excluding insignificant interstitial liquid removal activities in Section 4.3.2), with the liquid level in the waste tank at or below the bulk saltcake layers, by pumping**/jetting** liquid from **below** the saltcake **surface. Pumping/jetting liquid from below the saltcake surface where the bulk saltcake layer has supernate coverage is not considered saltcake interstitial liquid removal** [Ref. 1].

- Saltcake Well Mining: Saltcake well mining, considered as a bulk saltcake dissolution, is the process of dissolving saltcake, usually to allow insertion of equipment such as a pump**/jet** for saltcake interstitial liquid removal [Ref. 1].

- Waste Tanks in Gas Release Mode (GRM): Waste tanks are required to enter GRM prior to sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities if the GRM evaluation shows that the release of hydrogen due to sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities will cause the waste tank vapor space to exceed the Gas Release Criteria (see Section 4.3.2.1)

- Waste Tanks in Operation Mode: When in Operation Mode, liquid transfers in and out of the waste tanks are allowed. Sludge agitation, bulk saltcake dissolution, and saltcake interstitial liquid removal activities in the waste tanks are allowed provided the activities do not have the potential to cause the waste tank vapor space to exceed the Gas Release Criteria stated in Section 4.3.2.1. Chemical cleaning transfers are allowed into the waste tanks. Direct oxalic acid receipt to the waste tanks is prohibited. For more information, see Reference 6 Section 1.6.

- Waste Tanks in Acidic Chemical Cleaning Mode: Only Type I/II waste tanks are allowed to enter Acidic Chemical Cleaning Mode. Waste tanks in Acidic Chemical Cleaning Mode are allowed to store waste and operate chemical cleaning process provided:
  - Inhalation dose potential of waste is less than or equal to 3.98E+8 rem/gallon
  - Sludge remaining in the waste tank is less than or equal to 10,000 gallons
    For more information, see Reference 6 Section 1.6.

- Acidic Spray Washing: It is part of the chemical cleaning process to remove waste material from the tank walls and internal equipment and may be spray washed using oxalic acid, inhibited water or well water. Spray washing between acid sludge dissolution treatments can be conducted as needed [Ref. 1]. Acidic spray washing uses oxalic acid for spray washing activities.

- Waste Tanks in Non-Acidic Chemical Cleaning Mode: Only Type I/II waste tanks are allowed to enter Non-Acidic Chemical Cleaning Mode. Waste Tanks in Non-Acidic Chemical Cleaning Mode are allowed to store waste provided:
  - Inhalation dose potential of waste less than or equal to 3.98E+8 rem/gallon,
  - Sludge remaining in the waste tank less than or equal to 10,000 gallons,
  - pH of waste contents (e.g., waste from previous chemical cleaning operations has been neutralized) greater than or equal to 7.
    For more information, see Reference 6 Section 1.6.

- Waste Tanks in Closure Mode: Only Type I, II and IV waste tanks are allowed to enter Closure Mode. Waste Tanks in Closure Mode are allowed to store waste provided:
  - Inhalation dose potential of waste less than or equal to 1.0E+12 rem,
  - Radiolytic hydrogen generation rate less than or equal to 0.5 ft^3/hr evaluated at 25°C with a NO_{eff} equal to zero.

    For more information, see Reference 6 Section 1.6.

- Extended Sludge Processing (ESP) Sludge Slurry Waste Tank: A waste tank with a total radiolytic hydrogen generation greater than 19.6 ft^3/hr and less than or equal to 65.3 ft^3/hr. Only Waste Tanks 40 and 51 may be an ESP Sludge Slurry Waste Tank [Ref. 1].

- Hydrogen Concentration Safety Analysis Value (SAV): The Flammability Control Program establishes the hydrogen concentration SAV for a given tank (excluding Very Slow Generation Tanks, Tank 50 [as no hydrogen monitoring is required], waste tanks in Acidic Chemical Cleaning Mode and waste tanks in Closure Mode), when the waste tank is in GRM, Operation Mode, and Non-Acidic Chemical Cleaning Mode, such that the minimum time to reach the LFL is maintained based on the vapor space volume protected by the waste tank HLLCP [Ref. 1]. The hydrogen concentration SAVs, not including instrument uncertainty and organic contributions, cannot be less than 25% LFL and cannot exceed 60% LFL for hydrogen. The hydrogen concentration SAVs shall be on an individual tank basis and shall consider any proposed activities having the potential to release trapped gas (e.g., sludge agitation, bulk saltcake dissolution, interstitial liquid removal) [Ref. 1].

- TSR Hydrogen Concentration LFL Limit: TSR hydrogen concentration LFL limit (measured) is established by the Flammability Control Program according to the hydrogen concentration SAV designation of a given tank (excluding Tank 50, Very Slow Generation Tanks, waste tanks in Acidic Chemical Cleaning Mode, and waste tanks in Closure Mode). The TSR hydrogen concentration LFL limit shall be based on an individual tank basis and shall consider any proposed activities having the potential to release trapped gas (e.g., sludge agitation, bulk saltcake dissolution, and interstitial liquid removal). To determine the TSR hydrogen concentration LFL limit, the designated SAV is reduced to account for potential organics and instrument uncertainty [Ref. 1]. The TSR hydrogen concentration LFL limit will be designated in the ERD (excluding waste tanks discussed above). Once the ERD is approved, this will drive the revision of the Instrument Scaling and Setpoint Document, which will allow implementation of the required indicated hydrogen concentration reading in the facility. References 3, 4, and 31 provide instrument uncertainty values for a range of various SAVs, which are employed to determine the TSR hydrogen concentration LFL limit (i.e., indicated hydrogen reading).

  When the waste tanks are not in GRM, portable monitors [Refs. 5, 29, and 30] are used to measure the waste tank vapor space for comparison against the TSR hydrogen concentration LFL limits for Rapid Generation Tanks and Slow Generation Tanks while in Operation Mode or Non-Acidic Chemical Cleaning Mode, and waste tanks in Acidic Chemical Cleaning Mode. The instrument uncertainty value selected in the development of the TSR hydrogen concentration LFL limit where portable monitors are utilized shall be the highest uncertainty value for the available portable monitoring equipment used in the Tank Farm. For example, the MSA Model 261 multigas monitor has a larger uncertainty than the MSA Watchman

multigas monitor or the RKI Eagle 2 multigas monitor. The uncertainty value for the Model 261 would be selected for determining the TSR hydrogen concentration LFL limit. This permits any one of the three instruments to be used for manually monitoring hydrogen concentration per the TSRs.

For activities where entry into GRM is required (refer to Section 4.3.2.3), the TSR hydrogen concentration LFL limits, established by the Flammability Control Program, shall ensure the minimum time to LFL, defined by the tank classification, is maintained [Ref. 1].

- High Liquid Level Conductivity Probes (HLLCP): In order to detect high waste levels in the primary tank, conductivity probes, with an associated control room alarm, are installed in each waste tank, and suspended at, or below, the desired maximum fill level [Ref. 1].

- Time to LFL: The time it takes for the hydrogen in the waste tank vapor space to reach the LFL_{OC} from an assumed initial hydrogen concentration.

- Radiolytic Time to LFL (excluding Tank 50): This is the time for the hydrogen concentration to go from SAV (nominally 25% the LFL_T) to the LFL_{OC}. The time to LFL is calculated based on the waste tank volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program [see Section 4.4], flammable vapor contributions from trace organics, and radiolytic hydrogen generation, considering atmospheric breathing rate only.

- Radiolytic Time to LFL (Tank 50): This is the time for the hydrogen concentration to go from 3.8% of the LFL_T to the LFL_{OC}. The time to LFL is calculated based on the waste tank volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program [see Section 4.4], flammable vapor contributions from radiolytic hydrogen generation, considering atmospheric breathing rate only.

- Spontaneous Time to LFL (excluding Tank 50): This is the time for the hydrogen concentration to go from 25% the LFL_T to the LFL_{OC}. The time to LFL is calculated based on the actual/projected waste tank level, flammable vapor contributions from trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation, considering atmospheric breathing rate only.

- Spontaneous Time to LFL (Tank 50): This is the time for the hydrogen concentration to go from 3.8% of the LFL_T to the LFL_{OC}. The time to LFL is calculated based on the actual/projected waste tank level, flammable vapor contributions from trapped gas release from slurried sludge and radiolytic hydrogen generation, considering atmospheric breathing rate only.

- Rapid Generation Tanks: Rapid Generation Tanks are waste tanks that have the time to reach the LFL_{OC} greater than or equal to 7 days and less than 28 days following a loss of ventilation.

- Slow Generation Tanks: Slow Generation Tanks are waste tanks that have the time to reach the LFL_{OC} greater than or equal to 28 days following a loss of ventilation.

- Very Slow Generation Tanks: Very Slow Generation Tanks are waste tanks that never reach LFL_{OC}.

- Seismic Time to LFL: For Rapid and Slow Generation Tanks, it is the time it takes for the hydrogen concentration to go from 2.5% of the LFL_T (3.8% of the LFL_T for Tank 50) or radiolytic hydrogen equilibrium concentration, accounting for minimum ventilation flow, whichever is higher, to the LFL_{OC} following a seismic event. For Very Slow Generation Tanks, it is the time it takes for the hydrogen concentration to go from the radiolytic hydrogen equilibrium concentration, accounting for atmospheric breathing, to the LFL_{OC} following a seismic event [Ref. 1]. Seismic time to LFL is calculated based on the actual/projected waste tank level, flammable vapor contributions from trace organics, trapped gas release from solids (e.g., saltcake, settled sludge, slurried sludge), and radiolytic hydrogen generation.

- Priority 1 Tanks: Waste tanks that can reach 100% of the LFL_{OC} in less than 24 hours assuming no ventilation and including the effects of post-seismic trapped gas release.

- Priority 2 Tanks: Waste tanks that can reach 100% of the LFL_{OC} in greater than or equal to 24 hours and less than 7 days assuming no ventilation and including the effects of post-seismic trapped gas release, and waste tanks in the Acidic Chemical Cleaning Mode.

- Quiescent Time: It is the allowable time between waste tank mixing device operations such that the hydrogen released from the applicable settled sludge and/or slurried sludge does not cause the waste tank vapor space to exceed the applicable Quiescent Time criteria.

- $t_{seismic}$: Seismic Quiescent Time – The Seismic Quiescent Time protects the waste tank vapor space from reaching LFL_{OC} in less than 7 days post-seismic event (due to trapped gas released from settled sludge and slurried sludge, and subsequent radiolytic hydrogen production) [Ref. 1].

- $t_{spontaneous}$: Spontaneous Quiescent Time - This quiescent time protects the waste tank flammability classification during a spontaneous release event [Ref. 1].

- t_{NFPA}: National Fire Protection Association (NFPA) Spontaneous Quiescent Time – The NFPA Quiescent Time protects the waste tank vapor space from reaching 60% of LFL_T due to spontaneous release of trapped hydrogen gas from slurried sludge.

- t_{GRM}: GRM Quiescent Time – The GRM Quiescent Time protects the waste tank vapor space from exceeding the GRM criteria.

- Q_{H2}: Temperature corrected hydrogen generation rate – Volumetric flow rate of hydrogen generated from the radiolytic decomposition of water.

- H_{mix}: Fraction of hydrogen in the gas trapped in saltcake, settled sludge or slurried sludge.

- Q_{ATM}: Atmospheric breathing rate – Volumetric flow rate of air breathing through the opening size of a waste tank (e.g., riser plugs, penetrations). Q_{ATM} is calculated using the waste tank vapor space volume protected by the HLLCP setpoint.

- Q'_{ATM}: Atmospheric breathing rate – Volumetric flow rate of air breathing through the opening size of a waste tank (e.g., riser plugs, penetrations). Q'_{ATM} is calculated using the waste tank vapor space volume based on the actual/projected waste tank level.

- V_V: Waste tank vapor space volume – Vapor space volume protected by HLLCP setpoint.

- V'_V: Waste tank vapor space volume – Vapor space volume calculated based on the actual/projected waste tank level.

- H_{eq}: Hydrogen concentration at equilibrium conditions with hydrogen generated from radiolytic decomposition of water, considering atmospheric breathing, calculated using the waste tank vapor space volume protected by the HLLCP setpoint.

- $H_{eq(Rapid/Slow)}$: Vapor space hydrogen concentration at equilibrium conditions with hydrogen generation from radiolytic decomposition of water for Rapid and Slow Generation Tanks. $H_{eq\ (Rapid/Slow)}$ is calculated accounting for DSA purge ventilation flow (e.g., 72 ft^3/min for Rapid Generation Tanks or 45 ft^3/min for Slow Generation Tanks).

- H'_{eq}: Vapor space hydrogen concentration at equilibrium conditions with hydrogen generated from radiolytic decomposition of water. H'_{eq} is calculated using the actual waste tank vapor space volume, accounting for atmospheric breathing.

- C: Pressure correction factor – An expansion factor that accounts for the effect of pressure on trapped bubble gas release.

- P_{avg}: Hydrostatic head pressure.

- F_R: Volume fraction of trapped gas released from solids layer (e.g., saltcake, settled sludge, slurried sludge).

- G_S: Volume fraction of trapped bubble gas in solids layer (e.g., saltcake, settled sludge, slurried sludge).

- TG: Concentration of trapped hydrogen gas released from solids layer (e.g., saltcake, settled sludge, slurried sludge).

- TG_{SS}: Concentration of trapped hydrogen released from slurried sludge.

- V_T: Total tank vapor space volume (empty tank).

- MMW: Missing waste volume to account for maximum volume associated with a Transfer Error event.

- IU: Instrument uncertainty attributed to the HLLCP.

- y_0: Initial hydrogen concentration in the waste tank vapor space at temperature T.

- $y_{0(25C)}$: Initial hydrogen concentration in the waste tank vapor space at 25°C.

- $y_{0,seismic}$: Initial hydrogen concentration in the waste tank vapor space following a seismic event.

- V_{solids}: Volume of solids layer (e.g., saltcake, slurried sludge or settled sludge) in the waste tank.

- $V_{solids\ pump}$: Volume of solids layers below the pump/**jet** suction

- H_R: Percentage of hydrogen generated that is retained in the slurried sludge.

- L_{HLLCP}: Level of HLLCP setpoint.

- L_{tank}: Level of waste (actual or projected).

- ΔV_{H_2}: Volume of trapped hydrogen gas released per inch of free supernate removed.

- Ff: Nominal waste tank fill factor - The nominal waste tank fill factors (i.e., 2,710 gal/in for Type I waste tanks; 3,500 gal/in for Type II waste tanks; 3,510 gal/in for Type III/IIIA waste tanks; 3,540 gal/in for Type IV waste tanks) may be used to calculate the waste volumes to support implementation of DSA Administrative Controls (e.g., Flammability Control Program) [Ref. 1]. For more detailed values of waste tank volumes as a function of waste tank fill height, see Reference 41.

- Vapor space and trapped gas temperature limits used in the flammability calculations may use the supernate temperature limits protected by the Corrosion Control Program [Ref. 8], not to exceed 100ºC [Ref. 1]. As an alternative to using the corrosion control supernate temperature limits, an engineering evaluation may be performed to set maximum flammability temperature limits. These temperature limits are used to correct the flammability calculations to account for temperature variations. For inactive, dry tanks with no specified supernate temperature limit, a temperature limit of 75°C shall be used for the flammability calculations [Ref. 33]. For evaporator drop tanks during evaporator operation (and 7 days following the termination of evaporator operation), the corrosion supernate

temperature limits are suspended [Ref. 8]. However, during this period, the flammability supernate temperature limits are applied to these tanks for flammability calculations. For Tank 50, the bulk supernate temperature limit of 43ºC is to be used for the flammability calculations [Refs. 1, 24].

- Unless otherwise noted, dissolved hydrogen contributions are not considered because of the following [Ref. 1]:
  - Typical of waste tanks, small temperature increases correspond to insignificant amounts of dissolved hydrogen released.
  - Waste agitation from seismic motion will release insignificant, if any, quantities of dissolved hydrogen.
  - Dissolved hydrogen release due to mixer operation is not a prompt release.
  - The minimum ventilation flow rates required for Rapid and Slow Generation Tanks (i.e., 45 scfm and 72 scfm) account for dissolved hydrogen release from steam jetted transfers (excluding Tank 50, Type I/II Chemical Cleaning Waste Tank, and Tanks 40 and 51 when classified as ESP Sludge Slurry Waste Tanks).
  - Continuous purge by the waste tank ventilation system (minimum flow rate of 45 scfm) on Very Slow Generation Tanks (excluding Tank 50, Type I/II Chemical Cleaning Waste Tank, and Tanks 40 and 51 when classified as ESP Sludge Slurry Waste Tanks) is sufficient to account for dissolved hydrogen release when receiving steam jetted transfers.
- Organic flammability contributions due to trace organics are considered bounded by 5% of the LFL for hydrogen, except for Tank 50, which includes contributions from Isopar® L (51.2% of the CLFL at 43°C) in addition to the 5% of the LFL [Ref. 24] due to trace organics. The Waste Acceptance Criteria Program [TSR SAC 5.8.2.15] shall ensure that waste streams received into the facility are sufficiently characterized to demonstrate compliance with the organic contribution to flammable vapors (evaluated at 100°C). The organic contribution is accounted for in the time to LFL calculations. Within CSTF, very minor, if any, organics are added (e.g., defoamers for evaporators) and are fully covered by the 5% LFL assigned for organics by the following programs:
  - The Chemical Inventory Control Program shall provide control over new materials brought into the facility. [TSR AC 5.8.2.17]
  - The Oil Control Program shall be established to prevent the introduction (e.g., via air compressors, transfer pumps, waste tank mixing devices) of significant flammable vapors from lubricating or hydraulic oil into analyzed spaces (e.g., evaporator pots, evaporator cells, transfer facilities, waste tanks, and waste tank annuli) [Ref. 1]. This program is described in Section 4.7. [TSR AC 5.8.2.45]

  The contribution from organics for waste tanks is included in the temperature and organic-corrected LFL (LFL_{OC}). The 5% contribution to the hydrogen LFL from trace organics is

evaluated at 25°C, which is conservative compared to the Waste Acceptance Criteria requirement of 100°C.

- Flammability calculation inputs are dependent on the Waste Characterization System (WCS) Administrative Program [Ref. 10]. The input parameters and corresponding outputs for the flammability control program calculations are revised at the frequency that the WCS is updated. Such updates capture the Flammability Control Program requirements through the ERD linking procedure [Ref. 55].

- A waste tank may contain both types of sludge layers, settled sludge and slurried sludge; however, a slurried sludge layer cannot exist beneath a settled sludge layer. Each sludge type is defined below [Ref. 1]:
  - Settled sludge: sludge meeting the following criteria shall be considered settled sludge:
    - Sludge that has not been mixed (see discussion below) for greater than or equal to 15 years
    - Sludge receipts into a waste tank received greater than or equal to 15 years (see discussion below)
  - Slurried sludge: sludge meeting the following criteria shall be considered slurried sludge:
    - Sludge that has been mixed (see discussion below) less than 15 years ago.
    - Sludge receipts into a waste tank received less than 15 years ago, except as discussed below.

    Sludge received during DWPF recycle transfers, Canyon transfers or transfers from settled sludge waste tanks with the transfer device suction at or above the sludge layer can be considered to be settled sludge immediately (due to limited quantities), provided both of the following criteria apply:

    - No waste tank mixing device operation (which created slurried sludge) occurred in the receipt tank in the 15 years prior to the date the sludge was received, or after the date of receipt.
    - No slurried sludge was received into the waste tank within the past 15 years.

    Operating a mixing device in a waste tank is considered to create slurried sludge from any settled sludge within the zone of influence of the mixing device, after the mixing device has operated for a cumulative total of 10 days with turntable rotating and indication of sludge mixing. Additionally, sludge that has been within the zone of influence of an operating waste tank mixing device (i.e., based on tank cross sectional area and sludge disturbance depth as defined in Section 4.3.2.2 Variable V_{solids} Calculation for settled sludge agitation) will be considered slurried sludge, irrespective of requirements previously stated, if any mixing device in the waste tank is lowered. Sludge that does not fully meet one of these criteria may continue to be considered settled sludge. If any waste tank mixing device is lowered prior to 10-day mixing operation, the affected sludge layer within the zone of influence of the waste tank mixing device (prior to lowering) shall be considered slurried sludge [Ref. 1].

    For waste tanks that are undergoing initial sludge agitation, multiple waste tank mixing devices will typically be used to ensure a sludge layer within a waste tank (or entire

sludge inventory) has been slurried (and thus be considered slurried sludge). However, a process upset under certain waste tank conditions (e.g., failure of slurry pumps / CSMPs during slurrying with a remaining single slurry pump / CSMP operated for cumulative total of 10 days), could result in only a portion of the sludge layer to become slurried sludge. Engineering evaluation can be performed to estimate the amount of slurried sludge created by this process upset [Ref. 1].

For waste transfers that do not meet the Sludge Carryover Criteria defined in the Sludge Carryover Minimization (SCOM) Program, a methodology has been developed to estimate the volume of sludge entrained during the transfers [Ref. 9]. Alternatively, an engineering evaluation can be performed to determine the sludge transfer volume. The type of sludge transferred (i.e., settled sludge vs. slurried sludge) is determined by the criteria previously defined.

Supernate transfers (transfers that meet the Sludge Carryover Minimization Program) from one waste tank into another waste tank do not contain sludge for the purpose of determining slurried sludge receipts.

- Saltcake, settled sludge, slurried sludge, and liquid level can be determined by measurement, visual inspection, or by engineering evaluation. Engineering shall identify the selected methodology. Soundings provide direct measurement using a tape with a wafer (for settled sludge) or a spike (for saltcake) by comparison to the known elevation of the riser being used. Turbidity meters provide direct measurement of the slurried sludge level using the scattered light meter by comparison to the known elevation of the riser being used. Visual inspections may be by direct observation or via camera by comparison to the known waste tank component elevations. Use of an engineering evaluation for saltcake / settled sludge / slurried sludge level determination shall address applicable parameters described below. Tank liquid level can be measured by reel tape, radar, etc. These values (saltcake, settled sludge, slurried sludge, and liquid level) are used to determine waste tank characteristics for calculation of hydrogen generation rate and amount of trapped gas retained/released.

  When selected, engineering evaluations for saltcake / settled sludge / slurried sludge level determination shall address the following attributes, as applicable, for the specific waste tank:

  - Process knowledge (e.g., transfer history, operational conditions)
  - Historical saltcake / settled sludge / slurried sludge level determinations
  - Waste tank sample results
  - Uniformity of the solids level (saltcake / settled sludge / slurried sludge), as described below

  It is recognized that the solids layer (i.e., saltcake, settled sludge, slurried sludge) level within a waste tank may not be at a uniform level across the tank (e.g., layer slopes downward from one side of the tank). The engineering evaluation shall consider this in determining the solids layer volume from the level determination. Although the highest measured or visually determined value may be used to define the level of the entire layer, this may produce an

unreasonably conservative value for use in flammability evaluations. Known parameters of the layer (e.g., approximate slope of a settled sludge layer, mapping) may be utilized to estimate a more reasonable actual volume of the layer.

3.1 IMPLEMENTATION ACTIONS

1. Supernate temperature limits imposed by the Corrosion Control Program [Ref. 8] may be used in flammability calculations, with the following exceptions:

   - Alternative temperature limits may be set by engineering evaluation
   - Inactive, dry tanks with no specified supernate temperature limit shall use 75°C for flammability calculations [Ref. 33]
   - Tank 50 shall use 43°C for flammability calculations [Ref. 24]
   - The limits cannot exceed 100ºC [Ref. 1].

2. Flammability calculations shall account for the contribution of 5% of the hydrogen LFL due to trace organics, except for Tank 50. Tank 50 shall account for contributions from Isopar® L (51.2% of the CLFL at 43°C) in addition to the 5% of the CLFL due to trace organics [Ref. 24].

3. Solids (e.g., saltcake, settled sludge, slurried sludge) volume/height shall be calculated based on measurements obtained using salt/sludge soundings or turbidity meters (for sludge), or determined per engineering evaluation and shall be tracked in WCS [Ref. 11], as applicable [Ref. 1].

4. Prior to a sludge slurry transfer, an engineering evaluation shall be performed to estimate the volume of settled sludge/slurried sludge entrained during the transfer. The methodology to estimate the volume of settled sludge/slurried sludge transferred is provided in the SCOM Program PDD [Ref. 9]. As an alternative to using this methodology, an engineering evaluation may be performed by using the following attributes, as applicable [Ref. 1]:

   - Engineering principles (e.g., fluid flow mechanics)
   - Engineering modeling (e.g., Computational Fluid Dynamics)
   - Equipment characteristics (e.g., pump curves, suction orientation)
   - Process knowledge (e.g., weight percent solids from sample at a specific level)

5. After completion of a sludge slurry transfer, a re-baseline of the waste tank solids layers (e.g., settled sludge, slurried sludge, saltcake) may be performed. The resulting levels of settled sludge and slurried sludge may be input into WCS [Ref. 11] to provide an updated waste tank flammability status [Ref. 1].

6. The date slurried sludge is received in a waste tank or the date settled sludge becomes slurried sludge shall be tracked in WCS [Ref. 11].

4.0 PROGRAM DESCRIPTION

Section 4.8 lists ISB requirements other than those in the DSA and TSR. The ISB requirements supersede the requirements of this PDD for the affected sections.

4.1 FLAMMABILITY CONTROL PROGRAM

4.1.1 BACKGROUND

The primary flammable vapor of concern in the CSTF is hydrogen. The primary source of hydrogen is the radiolytic decomposition of water except during Chemical Cleaning of Type I/II Waste Tanks where hydrogen generation from corrosion of carbon steel is an additional source. Hydrogen can be released directly into the vapor space or can be retained in the waste. The retained hydrogen is either captured in the supernate (i.e., dissolved hydrogen) or in the saltcake/sludge (i.e., trapped hydrogen). The dissolved hydrogen is continuously released from the supernate, with the rate being dependent on the supernate characteristics (e.g., temperature, chemistry). The dissolved hydrogen release from the supernate due to supernate agitation, mixer operation, and seismic motion is not considered a significant independent hydrogen source and therefore is not credible in the absence of ventilation (see Section 3.0). Trapped hydrogen gas is assumed to be released from sludge when the sludge is agitated (e.g., seismic event, waste tank mixing device operation), the static head pressure on the sludge is reduced (e.g., free supernate removal), or the spontaneous liberation of gas bubbles from the slurried sludge layer occurs. Trapped hydrogen gas is assumed to be released from saltcake during saltcake dissolution, during seismically initiated agitation (due to mobilization from liquid sloshing), during saltcake interstitial liquid removal, or from the reduction in static pressure (e.g., free supernate removal). The trapped hydrogen gas release rates are dependent on the characteristics of the saltcake/sludge and the cause of the release [Ref. 1]. Hydrogen is naturally buoyant in air and diffuses readily; therefore, hydrogen released to vapor spaces from radiolytic decomposition and corrosion as discussed above is assumed to be well mixed (i.e., no hydrogen layering) and only bulk hydrogen concentrations are considered.

The CSTF Flammability Control Program applies to all waste tanks (except as described in Section 2.0) due to the presence of hydrogen and potentially flammable organic vapors. Waste tank flammability classifications and waste tanks that can reach 100% of the LFL in less than 7 days assuming no ventilation and including the effects of post seismic trapped gas release shall be determined and documented in the ERD using the methodology in the program for tanks in Gas Release Mode, Operation Mode, and Non-Acidic Chemical Cleaning Mode. Tanks in Non-Acidic Chemical Cleaning Mode shall be subject to the same Flammability Control Program controls as tanks in Operation Mode.

The Flammability Control Program does not apply to loss of ventilation for waste tanks in Acidic Chemical Cleaning Mode, with the exception of tracking the flammability status and the emergency response priority in the ERD [Ref. 2]. Tanks in Acidic Chemical Cleaning Mode have been determined to reach the LFL in 3 days and will require minimum purge flow to protect the initial hydrogen concentration of 25% of the LFL in the tank vapor space [Ref. 34]. The purge flow analysis includes the release of trapped gas during Acidic Chemical Cleaning. Response times to loss of ventilation for tanks in Acidic Chemical Cleaning Mode are prescribed

by LCOs 3.8.15 and 3.8.18 for the tank primary and annulus, respectively [Ref. 6]. Acidic Chemical Cleaning Tanks shall be included in the number of tanks that can reach the LFL in less than 7 days following a seismic event.

The Flammability Control Program does not apply to loss of ventilation for waste tanks in Closure Mode. Requirements for waste tanks in Closure Mode are given in Section 4.6. Due to the low waste volume, there is negligible impact to time to LFL for trapped gas release.

The Flammability Control Program is established to protect the assumed time to LFL (CLFL for Tank 50) in individual waste tanks upon loss of ventilation and minimizes the number of tanks that can become flammable in 24 hours or 7 days assuming no ventilation and including the effects of post-seismic trapped gas release. The program shall include the following attributes [Ref. 6]:

- Determine and track the time to LFL (CLFL for Tank 50) for waste tanks in order to determine the individual waste tank flammability classification (Rapid Generation Tanks, Slow Generation Tanks, Very Slow Generation Tanks, Chemical Cleaning Tanks). Document the waste tank flammability classification for each waste tank in the ERD (N-ESR-G-00001). [TSR SAC 5.8.2.27.a]

- Determine the waste tank hydrogen concentration SAV and hydrogen concentration LFL limit, excluding Tank 50, Very Slow Generation Tanks, and waste tanks in Acidic Chemical Cleaning Mode. The hydrogen concentration LFL limit shall be based on the hydrogen concentration SAV and shall account for potential organics and instrument uncertainties. Document the waste tank hydrogen concentration LFL limit for each waste storage tank in the ERD (N-ESR-G-00001). [TSR SAC 5.8.2.27.b]

- Ensure that it takes a minimum of 7 days upon loss of waste tank forced ventilation (based on the methodology for waste tank flammability classification) for the tank bulk vapor space to reach 100% of the LFL (CLFL for Tank 50), excluding Very Slow Generation Tanks, and waste tanks in Acidic Chemical Cleaning Mode. [TSR SAC 5.8.2.27.c].

- Determine, track, and ensure that only 7 waste tanks can reach 100% of the LFL in less than 24 hours assuming no ventilation and including the effects of post-seismic trapped gas release. Document the waste tank prioritization results in the ERD (N-ESR-G-00001). [TSR SAC 5.8.2.27.d]

- Determine, track, and ensure that only 14 waste tanks can reach 100% of the LFL in less than 7 days including [TSR SAC 5.8.2.27.e]:
  - Effects of post-seismic trapped gas release, assuming no ventilation
  - Number of waste tanks in Acidic Chemical Cleaning Mode

  Document the waste tank prioritization results in the ERD (N-ESR-G-00001) [Ref. 2].

  Waste tank priorities are defined based on the time for the hydrogen concentration in the vapor space to reach 100% of the LFL assuming no ventilation and including the effects of post-seismic trapped gas release. Priority 1 refers to waste tanks that may become flammable

in less than 24 hours. Priority 2 refers to waste tanks that have greater than or equal to 24 hours but less than 7 days to become flammable. Waste tanks that are in Acidic Chemical Cleaning Mode are also classified as Priority 2 (as these waste tanks have an assumed time to LFL of three days).

- Programmatic controls shall be established to ensure a path forward is provided to DOE (addressing the additional risk and recovery time) if a transfer required to mitigate a waste tank leak causes additional waste tanks (more than 14) to have the potential to become flammable in less than 7 days. The path forward is not required to be provided to DOE prior to initiating the transfer. [TSR A/C 5.8.2.27.f]

4.1.2 TIME TO LFL

4.1.2.1 WASTE TANK FLAMMABILITY CLASSIFICATION

The waste tank flammability classifications are designated according to the time it takes to reach 100% of the temperature and organic corrected LFL for hydrogen, (LFL_{OC}), following a loss of ventilation by the following criteria [Ref. 1]:

- Rapid Generation Tanks are waste tanks that have a time to reach the LFL_{OC} of less than 28 days following a loss of ventilation.
- Slow Generation Tanks are waste tanks (excluding Very Slow Generation Tanks) that have a time to reach the LFL_{OC} of greater than or equal to 28 days following a loss of ventilation.
- The time to LFL is determined as the lower of the radiolytic time to LFL or the spontaneous time to LFL.
  - Waste tanks excluding Tank 50
    - Radiolytic Time to LFL is the time it takes for the waste tank vapor space to go from the hydrogen concentration SAV (nominally 25% of the temperature corrected LFL [LFL_T]) to the LFL_{OC}. The time to LFL is calculated based on the vapor space volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program), flammable vapor contributions from trace organics and radiolytic hydrogen generation, considering atmospheric breathing rate only.

    - Spontaneous Time to LFL is the time it takes for the waste tank vapor space to go from 25% of the LFL_T to the LFL_{OC}. The time to LFL is calculated based on the actual/projected waste contents and vapor space volume, flammable vapor contributions from trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation, considering atmospheric breathing rate only.

    For Rapid and Slow Generation Tanks, the SAV is nominally set at 25% of the LFL_T. For planned gas release activities, the SAV may be increased within a range of 25% to 60% to allow for a larger hydrogen release, but it will reduce the time to LFL upon loss of ventilation in the waste tank. The SAV must be set such that the minimum times to LFL for Rapid and Slow Generation Tanks are protected.

  - Tank 50

- Radiolytic Time to LFL has been determined to go from 3.8% of the LFL_T to the LFL_{OC}. The tank time to LFL is calculated based on the vapor space volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program), flammable vapor contribution from radiolytic hydrogen generation, considering atmospheric breathing rate only.

- Spontaneous Time to LFL has been determined to go from 3.8% of the LFL_T to the LFL_{OC}. The time to LFL is calculated based on the actual/projected waste contents and vapor space volume, and flammable vapor contributions from trapped gas release from slurried sludge and radiolytic hydrogen generation, considering atmospheric breathing rate only.

  For Tank 50, the purge flow is shown to be able to maintain the vapor space less than or equal to 60% of the CLFL when Tank 50 is classified as a Slow or Rapid tank. Because Tank 50 is assumed to have 51.2% of the CLFL due to Isopar® L and 5% due to trace organics, the concentration of hydrogen that can be maintained in Tank 50 is 60% - 51.2% - 5% = 3.8% [Refs. 1, 24]. Therefore, a hydrogen concentration of 3.8% corresponds to a total vapor space flammable concentration of 60% of the CLFL.

- Very Slow Generation Tanks are waste tanks whose times to reach the LFL_{OC} (i.e., radiolytic time to LFL and spontaneous time to LFL) are infinite and must meet both of the following criteria.
  - Radiolytic Time to LFL has been determined to never reach the LFL_{OC} at equilibrium conditions. The tank classification is calculated based on the vapor space volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program), and flammable vapor contribution from Isopar® L (Tank 50 only), trace organics, and radiolytic hydrogen generation, considering atmospheric breathing rate only.

  - Spontaneous Time to LFL has been determined to never reach the LFL_{OC} at equilibrium conditions. The tank classification is calculated based on the actual/projected waste contents and vapor space volume, and flammable vapor contributions from Isopar® L (Tank 50 only), trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation, considering atmospheric breathing rate only.

Waste tanks for which the time to LFL has the potential to fluctuate above and below one of the waste tank flammability classification criteria may remain classified at the more restrictive flammability classification. For example, waste tanks with the time to LFL of 28.5 days may remain classified as Rapid Generation Tanks.

4.1.2.2 TIME TO LFL METHODOLOGY

The DSA recognizes atmospheric breathing as a realistic transport mechanism for flammable vapors in the loss of normal tank ventilation. The following equation, derived from the hydrogen vapor space concentration equation in Reference 1, Section 3.4.1.1.2, provides the Flammability

Control Program time to LFL equation which accounts for the effects of atmospheric breathing:

Eq. #1 Time to LFL =
$$\frac{-\ln\left[\dfrac{LFL_{OC}-\dfrac{Q_{H2}}{Q_{H2}+Q_{ATM}}}{y_0-\dfrac{Q_{H2}}{Q_{H2}+Q_{ATM}}}\right]}{\dfrac{Q_{H2}+Q_{ATM}}{V_V}}$$

Where:

Time to LFL	=	Time it takes for the hydrogen concentration to go from the initial hydrogen concentration (y_0) to the temperature and organic corrected hydrogen concentration at 100% LFL (100% of the CLFL for Tank 50), hours
y_0	=	Initial hydrogen concentration, including temperature correction, vol. frac.
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL for all waste tanks except Tank 50. Due to the contribution of trace organics of up to 5% of the CLFL, and Isopar of up to 51.2% of the CLFL, LFL_{OC} for Tank 50 at 100% CLFL is calculated to be 43.8% of the CLFL (100% CLFL – 51.2% CLFL – 5% CLFL) or 43.8% of the hydrogen LFL at 43°C [Ref. 24], vol. frac.
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr
Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr
V_V	=	Vapor space volume, ft^3

Both the radiolytic time to LFL and the spontaneous time to LFL can be determined using Equation 1. Calculations of the variables listed in Equation 1 are provided in Section 4.1.2.2.1 for radiolytic time to LFL or Section 4.1.2.2.2 for spontaneous time to LFL.

The radiolytic and spontaneous times to LFL calculated using Equation 1 may return an error, due to attempting to calculate the natural log of a negative number, or return a negative time to LFL depending on the conditions of the indicated waste tank. The bullets below can be used to determine the waste tank times to LFL, if the waste tank conditions are met, prior to applying Equation 1 for time to LFL calculations.

- Radiolytic Time to LFL

For radiolytic time to LFL calculation, $\frac{Q_{H2}}{Q_{H2}+Q_{ATM}}$ is defined as H_{eq} (see Variable H_{eq} Calculation in Section 4.1.2.2.1). Substituting H_{eq} for $\frac{Q_{H2}}{Q_{H2}+Q_{ATM}}$ into Equation 1 yields

$$\text{Time to LFL} = \frac{-\ln\left[\frac{LFL_{OC}-H_{eq}}{y_0-H_{eq}}\right]}{\frac{Q_{H2}+Q_{ATM}}{V_V}}$$

- $H_{eq} < LFL_{OC}$: the waste tank vapor space never becomes flammable. The waste tank radiolytic time to LFL is infinite and Equation 1 is not required.
- $H_{eq} > LFL_{OC}$ and $H_{eq} > y_0$: the waste tank time to LFL can be determined using Equation 1 and the methodology in Section 4.1.2.2.1.
- $H_{eq} > LFL_{OC}$ and $H_{eq} < y_0$: this condition never exists since $y_0 < LFL_{OC}$

- Spontaneous Time to LFL
  In the spontaneous time to LFL calculation, the waste tank vapor space is calculated based on the actual/projected waste tank level. Q_{ATM} and V_V in Equation 1 are replaced with Q'_{ATM} and V'_V. The initial hydrogen concentration is defined as the summation of the assumed initial hydrogen concentration plus the trapped gas released from slurried sludge, which is $y_0 + TG_{SS}$ and $\frac{Q_{H2}}{Q_{H2}+Q'_{ATM}}$ is defined as H'_{eq} (see Variable y_0 Calculation, Variable TG_{SS} Calculation, and Variable H'_{eq} Calculation in Section 4.1.2.2.2).
  Equation 1 becomes the following equation after substituting $y_0 + TG_{SS}$ for y_0, H'_{eq} for $\frac{Q_{H2}}{Q_{H2}+Q_{ATM}}$ and V'_V for V_V into Equation 1.

$$\text{Time to LFL} = \frac{-\ln\left[\frac{LFL_{OC}-H'_{eq}}{y_0+TG_{SS}-H'_{eq}}\right]}{\frac{Q_{H2}+Q'_{ATM}}{V'_V}}$$

- $H'_{eq} + TG_{SS} < LFL_{OC}$, the waste tank vapor space never reaches flammable condition. The waste tank spontaneous time to LFL is infinite and Equation 1 is not required.

- $H'_{eq} < LFL_{OC}$ and $H'_{eq} < y_0 + TG_{SS}$
  - If $y_0 + TG_{SS} < LFL_{OC}$, the waste tank vapor space never reaches flammable condition. The waste tank spontaneous time to LFL is infinite and Equation 1 is not required.
  - If $y_0 + TG_{SS} \geq LFL_{OC}$, the waste tank spontaneous time to LFL is immediate and Equation 1 is not required.

- $H'_{eq} > LFL_{OC}$ and $H'_{eq} > y_0 + TG_{SS}$

- If $y_0 + TG_{SS} < LFL_{OC}$, the waste tank spontaneous time to LFL can be determined using Equation 1 and the methodology in Section 4.1.2.2.2.
- If $y_0 + TG_{SS} \geq LFL_{OC}$, the waste tank spontaneous time to LFL is immediate and Equation 1 is not required.

o $H'_{eq} > LFL_{OC}$ and $H'_{eq} < y_0 + TG_{SS}$

Since $y_0 + TG_{SS} > H'_{eq}$ and $H'_{eq} > LFL_{OC}$, $y_0 + TG_{SS} > LFL_{OC}$. The waste tank spontaneous time to LFL is immediate and Equation 1 is not required.

o $H'_{eq} < LFL_{OC}$ and $H'_{eq} > y_0 + TG_{SS}$

Since $y_0 + TG_{SS} < H'_{eq}$ and $H'_{eq} < LFL_{OC}$, $y_0 + TG_{SS} < LFL_{OC}$. The waste tank spontaneous time to LFL is infinite and Equation 1 is not required.

4.1.2.2.1 RADIOLYTIC TIME TO LFL

The waste tank radiolytic time to LFL is calculated using Equation 1 in Section 4.1.2.2. Calculations of variables y_0, LFL_{OC}, Q_{H2}, Q_{ATM} and V_v in Equation 1 are provided in this section. All variables/equations provided in this section are only applicable to this section unless otherwise noted.

VARIABLE y_0 CALCULATION – RADIOLYTIC TIME TO LFL

The initial hydrogen concentration, corrected for temperature, is determined by using the Burgess – Wheeler correlation, as follows:

Eq. #2 $$y_0 = y_{0(25C)} \cdot [1 - A \cdot (T - 25)]$$

Where:

y_0	=	Initial hydrogen concentration, including temperature correction, vol. frac.
$y_{0(25C)}$	=	Initial hydrogen concentration at 25°C, vol. frac. Waste tanks excluding Tank 50: nominally 25% but can go up 60% of the LFL for hydrogen at 25°C (LFL for hydrogen at 25°C is 0.04 vol. frac.) Tank 50: 3.8% of the LFL for hydrogen at 25°C
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^oC^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C (43°C for Tank 50) (see Variable T Calculation)

VARIABLE T CALCULATION

The vapor space temperature is assumed to be the same as the supernate phase. Vapor space temperatures used in the flammability calculations may use the supernate temperature limits protected by the Corrosion Control Program [Ref. 8], not to exceed 100°C [Ref. 1]. For Tank 50, the bulk supernate temperature limit of 43°C is to be used for flammability calculations [Refs. 1, 24].

As an alternative to using supernate temperature limits, an engineering evaluation may be performed to set maximum temperature limits. This temperature cannot exceed 100°C [Ref. 1]. These temperature limits are used to correct the flammability calculations to account for temperature variations.

VARIABLE LFL_{OC} CALCULATION

The LFL for hydrogen is 4.0% by volume (0.04-volume fraction) at room temperature conditions (i.e., 25°C). Since the LFL is temperature dependent, the LFL is adjusted for the various temperature conditions found in the CSTF using the Burgess – Wheeler Law [Ref. 1]. The Burgess-Wheeler Law provides an empirical correlation to correct the LFL to account for temperature variations. The Burgess – Wheeler correlation is documented in Section 3.4.1.1.2 of the DSA.

- **Waste tanks excluding Tank 50:** Using the same basis as the y_0 calculation (Equation 2), the LFL, corrected for organics and temperature, is determined by using the Burgess – Wheeler correlation and subtracting the organic contribution, as follows:

  Eq. #3 $$LFL_{OC} = LFL_{25C} \cdot \left[1 - A \cdot (T - 25)\right] - OC$$

  Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
OC	=	The organic contribution equivalent hydrogen concentration (i.e., 5% of LFL_{25C} (0.002-volume fraction)), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C (see Variable T Calculation)

- **Tank 50:** Due to the contribution of trace organics of up to 5% of the CLFL and Isopar of up to 51.2% of the CLFL, LFL_{OC} for Tank 50 at 100% of the CLFL is calculated to be 43.8% of the CLFL at 43°C or 43.8% of the LFL for hydrogen at 43°C [Ref. 24].

Eq. #4 $$LFL_{OC} = \frac{43.8}{100} \cdot LFL_{25C} \cdot [1 - A \cdot (43 - 25)]$$

Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$

VARIABLE Q_{H2} CALCULATION

The methodology used to calculate the total hydrogen generation rate (x_{H2}) is taken from Section 3.4.1.1.2 of the DSA and is the sum of the contribution from the radiolytic hydrogen generation and corrosion induced hydrogen generation (excluding acidic spray washing activities since the acid does not remain in contact with vertical tank surfaces for longer than 48 hours). The radiolytic hydrogen generation rate equations are based on experimental data that has had margin added (10%) [Ref. 50]. Therefore, the hydrogen generation rate calculations excluding waste tanks entering Closure Mode do not need to include additional analytical uncertainty [Ref. 1]. This total generation rate is:

Eq. #5 $$x_{H2} = x_{RAD} + x_{CORR}$$

Where:

x_{H2}	=	Total generation rate of hydrogen, ft^3/hr
x_{RAD}	=	Radiolytic hydrogen generation rate, ft^3/hr
*x_{CORR}	=	Corrosion induced hydrogen generation rate, ft^3/hr

*Applicable to waste tanks in Acidic Chemical Cleaning Mode, where the bounding rate is: 4.3E-05 ft^3 / min-ft^2 (Equation 11)

The radiolytic hydrogen generation rate at 25 °C is determined using the following equation:

Eq. #6 $$x_{RAD} = \frac{R_{\beta/\gamma} \cdot H_{\beta/\gamma} + R_{\alpha} \cdot H_{\alpha}}{10^6}$$

Where:

x_{RAD}	=	Radiolytic hydrogen generation rate at 25°C, ft^3/hr
$R_{\beta/\gamma}$	=	Volume (ft^3) of hydrogen generated per MBTU (10^6 British Thermal Unit) of heat added from beta or gamma decay
$H_{\beta/\gamma}$	=	Heat generated by beta and gamma decay, BTU/hr

R_α = Volume (ft^3) of hydrogen generated per MBTU of heat added from alpha decay

H_α = Heat generated by alpha decay, BTU/hr

The 10^6 in the denominator converts MBTU to BTU.

The values of R_α and $R_{\beta/\gamma}$ are dependent on the concentration of nitrate and nitrite in the waste and are given by Equations 7 and 8.

Eq. #7 $$R_\alpha = 134.7 - 82.3[NO_{eff}]^{1/3} - 13.6[NO_{eff}]^{2/3} + 11.8[NO_{eff}]$$

Eq. #8 $$R_{\beta/\gamma} = 48.36 - 52.78[NO_{eff}]^{1/3} + 14.1[NO_{eff}]^{2/3} + 0.572[NO_{eff}]$$

Where:

R_α = Volume (ft^3) of hydrogen generated per MBTU of heat added from alpha decay

$R_{\beta/\gamma}$ = Volume (ft^3) of hydrogen generated per MBTU (10^6 British Thermal Unit) of heat added from beta or gamma decay

NO_{eff} = The nitrate concentration ($[NO_3]$) plus one-half the nitrite concentration ($[NO_2]$) ($[NO_{eff}] = [NO_3] + \frac{1}{2}[NO_2]$, where concentrations are in units of mol/L)

The effective ion concentration ($[NO_{eff}]$) of the tank supernate is equal to the nitrate concentration plus one-half of the nitrite concentration. To address the potential for inadvertent transfers to the tanks, the NO_{eff} is diluted by the addition of 15,000 gallons of uninhibited water to account for maximum missing waste. As an alternative to using 15,000 gallons of uninhibited water, an engineering evaluation may be performed to evaluate the impact of an inadvertent transfer of 15,000 gallons of supernate from each waste tank on NO_{eff} [Ref. 23].

Application of the Corrosion Control Program dip sample analysis for $[NO_{eff}]$ values applied to supernate (including interstitial in the sludge, and salt layers) is a conservative practice, which minimizes the number of samples required to satisfy both Corrosion and Flammability Control Programs. Alternatively, variable depth samples can be used in conjunction with Corrosion Control samples to offer a more representative analysis of NO_{eff} of the bulk supernate for flammability purposes and are acceptable for use in the Flammability Control Program evaluations. This will be especially true of waste tanks where supernate stratification is suspected (e.g. evaporator feed tanks, drop and vent tanks, low density transfer into high density waste tanks, and rainwater in-leakage into waste tanks). The variable depth samples used in flammability calculations will be subject to the same requirements (i.e., sample frequency and grace period) as the dip sample analysis in the Corrosion Control Program [Ref. 8].

The $[NO_{eff}]$ used in dry salt tanks is based on the most recent sample results. As the evaporation process occurs in a salt tank, the supernate layer above the salt increases in salt concentration as

the liquid level recedes into the salt phase as interstitial liquid. Evaporation tends to increase [NO_{eff}] in the remaining liquid. Therefore, using the latest sample results is conservative.

The heat generated by alpha and beta/gamma decay is determined by the equations:

Eq. #9 $$H_{\alpha} = \sum_{i} Q_i . A_i$$

Eq. #10 $$H_{\beta/\gamma} = \sum_{j} Q_j . A_j$$

Where:

H_{α}	=	Total heat generated by alpha decay, BTU/hr
Q_i	=	Heat generated per curie for each isotope that decays by alpha, BTU/Ci-hr
A_i	=	Total activity of each isotope that decays by alpha, Ci
$H_{\beta/\gamma}$	=	Total heat generated by beta or gamma decay, BTU/hr
Q_j	=	Heat generated per curie for each isotope that decays by beta or gamma, BTU/Ci-hr
A_j	=	Total activity of each isotope that decays by beta or gamma, Ci

At a minimum the following isotopes must be considered when calculating the total heat: Sr-90, Y-90, Cs-137, Ba-137m, Ce-144, Pu-238, Pu-239, Am-241, Cm-244 [Ref. 1].

The corrosion induced hydrogen generation rate is determined using the following equation:

Eq. #11 x_{CORR} = Area Contacted . Rate

Where:

x_{CORR}	=	Corrosion induced hydrogen generation rate, ft^3/hr
Area Contacted	=	Surface area in contact with acidic waste, ft^2
Rate	=	Corrosion induced hydrogen generation rate per area, $ft^3/hr\text{-}ft^2$ (Reference 1 Section 3.4.1.5.5 gives value in $ft^3/min\text{-}ft^2$. Multiply by 60 min/hr to get in units of $ft^3/hr\text{-}ft^2$.)

If corrosion induced hydrogen generation is not a contributor, x_{CORR} is zero and the equation becomes:

Eq. #12 $x_{H2} = x_{RAD}$

Where:

x_{H2}	=	Total generation rate of hydrogen at 25°C, ft^3/hr
x_{RAD}	=	Radiolytic hydrogen generation rate at 25°C, ft^3/hr

The maximum hydrogen generation rates are provided below in addition to the tank flammability requirements (e.g. a Slow Generation Tank must have at least 28 days to LFL, following a loss of ventilation, and have a total radiolytic hydrogen generation rate less than or equal to the value stated below) [Ref. 1]:

- The maximum radiolytic hydrogen generation rate for a Rapid Generation Tank (excluding the third, fourth, and fifth bulleted items below) is 19.6 ft^3/hr. This total tank radiolytic hydrogen generation rate, in addition to the dissolved hydrogen release rate associated with transfers, is utilized for determining the required ventilation purge rate.

- The maximum radiolytic hydrogen generation rate for a Slow Generation Tank (excluding the third, fourth, and fifth bulleted items below) is 8.1 ft^3/hr. This total tank radiolytic hydrogen generation rate, in addition to the dissolved hydrogen release rate associated with transfers, is utilized for determining the required ventilation purge rate.

- The maximum radiolytic hydrogen generation rate for Tanks 40 and 51, when classified as an ESP Sludge Slurry Waste Tank, is 65.3 ft^3/hr. This total tank radiolytic hydrogen generation rate is utilized for determining the required ventilation purge rate.

- The maximum radiolytic hydrogen generation rate for Tank 50 (when classified as either a Rapid or Slow Generation Tank) is 2.8 ft^3/hr . This total tank radiolytic hydrogen generation rate is utilized for determining the required ventilation purge rate.

- The maximum radiolytic hydrogen generation rate for Type IV tanks is 3.2 ft^3/hr. This total tank radiolytic hydrogen generation rate, in addition to the dissolved hydrogen release rate associated with transfers, is utilized for determining the required ventilation purge rate.

Many of the accidents are assumed to occur at elevated temperatures; therefore, the radiolytic hydrogen generation rate is corrected for the higher temperatures using the Temperature Corrected Hydrogen Generation Rate methodology in Section 3.4.1.1.2 of the DSA.

Eq. #13 $$Q_{H2} = x_{H2} \cdot \frac{(T + 273)}{(T_i + 273)}$$

Where:

Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr
x_{H2}	=	Total hydrogen generation rate at temperature T_i, ft^3/hr
T	=	Temperature at which Q_{H2} is to be evaluated, ^oC (see Variable T Calculation)
T_i	=	Initial temperature at standard pressure of 1 atm, ^oC (e.g., 25°C [Ref. 1])

Variable Q_{H2} Calculation is applicable in other sections as noted.

VARIABLE Q_{ATM} CALCULATION - RADIOLYTIC TIME TO LFL

Atmospheric breathing reduces the hydrogen buildup in the vapor space and is therefore credited in this program. No specific controls for atmospheric breathing are required, since the design of the cell covers, penetrations, riser plugs, etc., is such that the locations crediting atmospheric breathing will have more than enough openings [Ref. 1]. The atmospheric breathing assumptions and methodology are established in the DSA, Section 3.4.1.5.5. The correlation for atmospheric breathing rate is determined using the following equation:

Eq. #14 $$Q_{ATM} = \left[\frac{\text{mean atm. fluctuation}}{1013}\right] \cdot \frac{V_V}{24}$$

Where:

Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr
mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V_V	=	Vapor space volume protected by HLLCP setpoint, ft^3, (see Variable V_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE V_V CALCULATION - RADIOLYTIC TIME TO LFL

The vapor space volume credited in calculating the radiolytic time to LFL following a loss of ventilation is the vapor space volume protected by the waste tank HLLCP setpoint, adjusted for instrument uncertainty and maximum missing waste. The following equation is the vapor space volume calculation, in cubic feet:

Eq. #15 $$V_V = 0.13368\,[V_T - (L_{HLLCP} + IU).Ff - MMW]$$

Where:

V_v	=	Vapor space volume, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
0.13368	=	Conversion factor from gallons to ft^3
L_{HLLCP}	=	HLLCP setpoint, inches
Ff	=	Nominal waste tank fill factor, gal/in, (see Section 3.0)
MMW	=	Maximum missing waste, equal to 15,000 gallons, to account for maximum volume associated with a Transfer Error event, gallons. MMW will be equal to 0 if the waste tanks are in Non-Acidic Chemical Cleaning Mode
IU	=	Uncertainty attributed to HLLCP, inches

VARIABLE H_{EQ} CALCULATION - RADIOLYTIC TIME TO LFL

The total hydrogen concentration at equilibrium conditions with hydrogen production from radiolytic decomposition, considering atmospheric breathing only, is used to determine whether the waste tank vapor space reaches a flammable condition at the steady state hydrogen concentration. The equilibrium hydrogen concentration for radiolytic time to LFL is represented in the following equation:

Eq. #16 $$H_{eq} = \frac{Q_{H2}}{Q_{H2} + Q_{ATM}}$$

Where:

H_{eq}	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} Calculation)
Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q_{ATM} Calculation)

H_{eq} will be used to determine whether the waste tanks can be designated as Very Slow Generation Tanks.

4.1.2.2.2 SPONTANEOUS TIME TO LFL

The waste tank spontaneous time to LFL is calculated in the same manner as the radiolytic time to LFL with changes to the initial hydrogen concentration, the waste tank vapor space volume based on the actual/projected tank level, and the flammable vapor contributions. Equation 1 in Section 4.1.2.2 can be used to determine the spontaneous time to LFL. Calculations of variables LFL_{OC} and Q_{H2} in Equation 1 can be found in Section 4.1.2.2.1. This section presents the equations used to calculate variables y_0, Q_{ATM} and V_v. Since V_v is based on actual/projected waste tank level, Q_{ATM} and V_v in Equation 1 will be replaced with Q'_{ATM} and V'_v. All variables/equations provided in this section are only applicable to this section unless otherwise noted.

VARIABLE y_0 CALCULATION – SPONTANEOUS TIME TO LFL

The initial hydrogen concentration, corrected for temperature, is determined by using the Burgess – Wheeler correlation, as follows:

Eq. #17 $$y_0 = y_{0(25C)} \cdot [1 - A \cdot (T - 25)] + TG_{SS}$$

Where:

y_0	=	Initial hydrogen concentration, including temperature correction, and trapped gas release from slurried sludge, vol. frac.
$y_{0(25C)}$	=	Initial hydrogen concentration at 25°C, vol. frac.

Waste tanks excluding Tank 50: 25% of the LFL for hydrogen at 25°C (LFL for hydrogen at 25°C is 0.04 vol. frac.)

Tank 50: 3.8% of the LFL for hydrogen at 25°C

A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C (43°C for Tank 50) (see Variable T Calculation in Section 4.1.2.2.1)
TG_{SS}	=	Volume fraction of trapped hydrogen gas released from slurried sludge, vol. frac. (see Variable TG_{SS} Calculation below)

VARIABLE TG_{SS} CALCULATION – SPONTANEOUS TIME TO LFL

The vapor space hydrogen concentration due to trapped gas release from slurried sludge is determined as follows:

Eq. #18 $$TG_{SS} = \frac{V_{SS} \cdot G_S \cdot H_{mix} \cdot C \cdot F_R}{V'_V}$$

Where:

TG_{SS}	=	Volume fraction of hydrogen released from slurried sludge, vol. frac.
V_{SS}	=	Volume of slurried sludge, gallons (see Variable V_{ss} Calculation)
G_S	=	Volume fraction of trapped bubble gas, vol. frac. (see Variable G_{Ss} Calculation)
H_{mix}	=	Volume fraction of hydrogen in trapped gas, vol. frac. (see Variable H_{mix} Calculation)
C	=	Pressure correction factor (see Variable C Calculation)
F_R	=	Volume fraction of trapped gas release (see Variable F_R Calculation)
V'_V	=	Vapor space volume using actual/projected waste tank level, gallons (see Variable V'_v Calculation)

VARIABLE V_{SS} CALCULATION – SPONTANEOUS TIME TO LFL

All the slurried sludge in the waste tank is considered to release hydrogen during a spontaneous liberation event and is used in determination of TG_{SS} [Ref. 1].

VARIABLE G_S CALCULATION – SPONTANEOUS TIME TO LFL

The maximum percentage of trapped bubble gas in slurried sludge is 20% by volume (0.20 volume fraction) [Ref. 1].

VARIABLE H_{MIX} CALCULATION

In waste tanks with known chemistry and heat loads, equations below which relate empirical

data (i.e., nitrite and nitrate concentrations) to the radiolytic decay heat may be used to calculate the fraction of hydrogen in the trapped bubble gas up to a maximum of 75% [Refs. 1, 48]. Otherwise, the hydrogen percent in trapped gas is determined as follows:

- 75% in waste tanks that contain slurried sludge (0.75 volume fraction)
- 50% in other waste tanks (e.g. tanks containing saltcake or settled sludge) (0.50 volume fraction)

Eq. #19 $H_{Mix} = H_{NO3} \cdot F_{NO3} \cdot G_{NO3} + H_{NO2} \cdot F_{NO2} \cdot G_{NO2}$

Where:

H_{Mix} = Hydrogen fraction in trapped gas (multiply by 100 to get in terms of percent)

H_{NO3} = Fraction of hydrogen in the gas produced by radiolysis of nitrate (see Equation 20)

H_{NO2} = Fraction of hydrogen in the gas produced by radiolysis of nitrite (see Equations 21, 22)

F_{NO3} = Fraction of nitrate in the supernate (see Equation 23)

F_{NO2} = Fraction of nitrite in the supernate (see Equation 24)

G_{NO3} = Hydrogen generation correction factor for NO_3 to account for nitrate/nitrite interaction in mixed solution (see Equation 25)

G_{NO2} = Hydrogen generation correction factor for NO_2 to account for nitrate/nitrite interaction in mixed solution (see Equation 26)

Eq. #20 $H_{NO3} = 0.0242[NO_3]^3 - 0.076[NO_3]^2 - 0.2101[NO_3] + 0.69$, for $[NO_3] \geq 0M$

Eq. #21 $H_{NO2} = 1.0213[NO_2]^2 - 1.2235[NO_2] + 0.9821$, for $[NO_2] < 1M$

Eq. #22 $H_{NO2} = 0.035[NO_2] + 0.74$, for $[NO_2] \geq 1M$

Eq. #23 $F_{NO3} = [NO_3] / ([NO_3] + [NO_2])$

Eq. #24 $F_{NO2} = [NO_2] / ([NO_3] + [NO_2])$

Eq. #25 $G_{NO3} = g_{Mix} / g_{NO3}$

Eq. #26 $G_{NO2} = g_{Mix} / g_{NO2}$

Where:

$[NO_3]$ = Nitrate concentration in supernate, mol/L

$[NO_2]$ = Nitrite concentration in supernate, mol/L

g_{Mix} = Hydrogen generation correction factor based on the concentration of NO_{eff} (see Equations 27 thru 30 with $[NO_{eff}]$ in place of $[NO_3]$)

g_{NO3} = Hydrogen generation correction factor based on the concentration of NO_3 (see Equations 27 thru 30)

g_{NO2} = Hydrogen generation correction factor based on the concentration of NO_2 (see Equations 27 thru 30 with 0.5*[NO_2] in place of [NO_3])

Eq. #27 $g_{NO3} = G_{\alpha NO3} \cdot a_{hf} + G_{\beta/\gamma\ NO3} \cdot (1-a_{hf})$

Eq. #28 $G_{\alpha NO3} = 1.3 - 0.79\ [NO_3]^{1/3} - 0.13\ [NO_3]^{2/3} + 0.11\ [NO_3]$

Eq. #29 $G_{\beta/\gamma NO3} = 0.466 - 0.51[NO_3]^{1/3} + 0.14[NO_3]^{2/3} + 0.0055[NO_3]$

Eq. #30 $ah_f = (H_{\alpha sludge} + H_{\alpha salt})/(H_{\beta/\gamma sludge} + H_{\alpha sludge} + H_{\beta/\gamma salt} + H_{\alpha salt})$

Where:

$G_{\alpha NO3}$ = Hydrogen yield in molecules per 100 electron volts of radiation produced by alpha radiation

$G_{\beta/\gamma NO3}$ = Hydrogen yield in molecules per 100 electron volts of radiation produced by beta/gamma radiation

ah_f = Fraction of radiolytic heat rate that is contributed to alpha radiation

$H_{\beta/\gamma sludge}$ = Heat generated by beta and gamma decay in the sludge, Btu/hr

$H_{\alpha salt}$ = Heat generated by alpha decay in the salt, Btu/hr

$H_{\alpha sludge}$ = Heat generated by alpha decay in the sludge, Btu/hr

Eq. #31 $[NO_{eff}] = [NO_3] + ½[NO_2]$

Where:

[NO_{eff}] = Effective ion concentration, mol/L

[NO_3] = Nitrate concentration in supernate, mol/L

[NO_2] = Nitrite concentration in supernate, mol/L

For sludge/salt tanks where water or inhibitor is added, the time for the water or inhibitor to diffuse into the interstitial liquid (5-10 years depending on particle size, density gradients and temperature gradients) is considered so long that the percent hydrogen in trapped gas is assumed to be unchanged; therefore, current chemistry (i.e., chemistry prior to the water/inhibitor addition) may be used to determine the hydrogen concentration in trapped gas for Gas Release evaluations [Ref. 16].

Variable H_{mix} Calculation is applicable in other sections as noted.

VARIABLE C CALCULATION – SPONTANEOUS TIME TO LFL

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release due to agitation. The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #32 $$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X} \right) + \frac{1}{2} \frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers above slurried sludge,
ρ_a	=	Density of layer material, kg/m³
ρ_1	=	Density of the slurried sludge layer material, kg/m³
h_a	=	Height of layer material, m
h_1	=	Height of the slurried sludge layer, m
g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325, Pa/atm

VARIABLE F_R CALCULATION – SPONTANEOUS TIME TO LFL

The percentage of trapped gas released from the slurried sludge due to spontaneous release is 100% (1.00 volume fraction).

VARIABLE H'_{EQ} CALCULATION – SPONTANEOUS TIME TO LFL

The equilibrium hydrogen concentration for spontaneous time to LFL is calculated in the same manner as the equilibrium hydrogen concentration for radiolytic time to LFL except the waste tank vapor space is determined using the actual/projected waste tank level.

Eq. #33 $$H'_{eq} = \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$$

Where:

H'_{eq}	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} Calculation in Section 4.1.2.2.1)
Q'_{ATM}	=	Atmospheric breathing rate, ft³/hr (see Variable Q'_{ATM} Calculation)

H'_{eq} will be used to determine whether the waste tanks can be designated as Very Slow Generation Tanks.

VARIABLE Q'_{ATM} CALCULATION – SPONTANEOUS TIME TO LFL

The correlation for atmospheric breathing rate for spontaneous time to LFL calculation is similar to the atmospheric breathing rate for radiolytic time to LFL calculation except the waste tank vapor space is determined using the actual/projected waste tank level.

Eq. #34 $$Q'_{ATM} = \left[\frac{\text{mean atm. fluctuation}}{1013}\right] \cdot \frac{V'_V}{24}$$

Where:

Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr
mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V'_V	=	Vapor space volume based on actual/projected waste tank level, ft^3, (see Variable V'_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE V'_V CALCULATION – SPONTANEOUS TIME TO LFL

The vapor space volume used to calculate the spontaneous time to LFL is based on the actual or projected waste level. The calculations account for the maximum missing waste volume when considering incoming transfers. The following equation is the vapor space volume calculation, in ft^3.

Eq. #35 $$V'_v = 0.13368\,[V_T - (L_{tank}.\,Ff) - MMW\,]$$

Where:

V'_V	=	Vapor space volume based on actual/projected waste tank level, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
0.13368	=	Conversion factor from gals to ft^3
L_{tank}	=	Actual/projected level, inches
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Missing waste volume, gallons (to be accounted for in the receipt tank for incoming transfers, see discussion below)

The waste tank level shall be adjusted to account for the maximum volume associated with a Transfer Error event (i.e., 15,000 gallons) for waste tanks receiving transfers from a sending vessel greater than or equal to 15,000 gallons or has continuous makeup capability. If the liquid batch source is less than 15,000 gallons and does not have continuous makeup capability, the waste tank level shall be adjusted to account for the maximum volume of the batch source. The liquid batch source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrically or mechanically isolated.

4.1.2.3 WASTE TANK FLAMMABILITY CLASSIFICATION DETERMINATION

The methodology in determining the radiolytic time to LFL and the spontaneous time to LFL is detailed in Section 4.1.2.2. The steps below can be used to as guidelines in determination of the waste tank flammability classification.

a. Calculate volume fraction of hydrogen concentration at equilibrium (H_{eq}) due to radiolytic hydrogen generation, using the vapor space volume protected by the waste tank HLLCP (see Section 4.1.2.2.1 Variable H_{eq} Calculation).
b. Calculate volume fraction of hydrogen concentration at equilibrium (H'_{eq}) due to radiolytic hydrogen generation, using the actual/projected waste tank level to determine the vapor space volume (see Section 4.1.2.2.2 Variable H'_{eq} Calculation).
c. Calculate volume fraction of trapped hydrogen gas released from slurried sludge (TG_{SS}), (see Section 4.1.2.2.2 Variable TG_{SS} Calculation).
d. Calculate the temperature and organic corrected hydrogen concentration at 100% of the LFL (LFL_{OC}) (see Section 4.1.2.2.1 Variable LFL_{OC} Calculation).
e. If $H_{eq} < LFL_{OC}$ AND $(H'_{eq} + TG_{SS}) < LFL_{OC}$, then the waste tank can be designated as a Very Slow Generation Tank.
f. If step e above is not met, then:
   - Waste tanks excluding Tank 50
     - Radiolytic time to LFL:
       - If $H_{eq} < LFL_{OC}$, radiolytic time to LFL is infinite. Go to step g.
       - If the condition above is not met, then calculate the radiolytic time to LFL starting from the SAV (nominally 25% of the LFL_T). Calculations are based on the vapor space volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program) and flammable vapor contributions from trace organics and radiolytic hydrogen generation, considering atmospheric breathing only (see Section 4.1.2.2.1).
     - Spontaneous time to LFL:
       - If $(H'_{eq} + TG_{SS}) < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.
       - If $H'_{eq} < (y_0 + TG_{SS}) < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.
       - If $(y_0 + TG_{SS}) < H'_{eq} < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.
       - If $(y_0 + TG_{SS}) \geq LFL_{OC}$, spontaneous time to LFL is immediate. Go to step g.
       - If the conditions above are not met, then calculate the spontaneous time to LFL starting from 25% of the LFL_T. Calculations are based on actual/projected waste level and flammable vapor contributions from trapped hydrogen gas released from slurried sludge, trace organics and radiolytic hydrogen generation, considering atmospheric breathing only (see Section 4.1.2.2.2).

     * y_0 can be determined using Equation 2 in Section 4.1.2.2.1. For spontaneous time to LFL calculation, $y_{0(25C)}$ is equal to 25% of the LFL for hydrogen at 25°C (LFL for hydrogen at 25°C is 0.04 vol. frac.).
   - Tank 50
     - Radiolytic time to LFL:
       - If $H_{eq} < LFL_{OC}$, radiolytic time to LFL is infinite. Go to step g.
       - If not, then calculate the radiolytic time to LFL starting from 3.8% of the LFL_T. Calculations are based on the vapor space volume protected by the waste tank HLLCP setpoint (and Tank Fill Limits Program) and flammable vapor contributions from radiolytic hydrogen generation, considering atmospheric breathing only (see Section 4.1.2.2.1).
     - Spontaneous time to LFL:
       - If $(H'_{eq} + TG_{SS}) < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.
       - If $H'_{eq} < (y_0 + TG_{SS}) < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.
       - If $(y_0 + TG_{SS}) < H'_{eq} < LFL_{OC}$, spontaneous time to LFL is infinite. Go to step g.

- If (y_0 + TG_{SS}) ≥ LFL_{OC}, spontaneous time to LFL is immediate. Go to step g.
- If not, then calculate the spontaneous time to LFL starting from 3.8% of the LFL_T. Calculations are based on actual/projected waste content and flammable vapor contributions from trapped hydrogen gas released from slurried sludge and radiolytic hydrogen generation, considering atmospheric breathing only (see Section 4.1.2.2.2).

* y_0 can be determined using Equation 2 in Section 4.1.2.2.1. For spontaneous time to LFL calculation, $y_{0(25C)}$ is equal to 3.8% of the LFL for hydrogen at 25ºC (LFL for hydrogen at 25ºC is 0.04 vol. frac.).

g. Waste tank flammability classification determination

- If radiolytic time to LFL is infinite (H_{eq} < LFL_{OC}) and spontaneous time to LFL is infinite ((y_0 + TG_{SS}) < LFL_{OC} AND H'_{eq} < LFL_{OC}), the waste tank can be designated as a Slow or Rapid Generation Tank.
- If radiolytic time to LFL is infinite (H_{eq} < LFL_{OC}) and spontaneous time to LFL is immediate ((y_0 + TG_{SS}) ≥ LFL_{OC}), the waste tank can be designated as a Slow or Rapid Generation Tank. The Spontaneous Liberation Protection Program will protect the waste tank vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification
- If radiolytic time to LFL is infinite and spontaneous time to LFL is a numeric value, the waste tank flammability classification will be determined based on the spontaneous time to LFL.
  - If spontaneous time to LFL ≥ 28 days, the tank can be designated as a Slow or Rapid Generation Tank.
  - If 7 days ≤ spontaneous time to LFL < 28 days, the tank shall be designated as a Rapid Generation Tank.
  - If spontaneous time to LFL < 7 days, the waste tank flammability classification shall be determined based on the time to LFL protected by the Spontaneous Liberation Protection Program. If the program protects 7 days, the waste tank shall be designated as a Rapid Generation Tank. If the program protects 28 days, the waste tank can be designated as a Rapid or Slow Generation Tank.
- If radiolytic time to LFL is a numeric value and spontaneous time to LFL is infinite, the waste tank flammability classification will be designated based on the radiolytic time to LFL
  - If radiolytic time to LFL ≥ 28 days, the tank can be designated as a Slow or Rapid Generation Tank.
  - If 7 days ≤ radiolytic time to LFL < 28 days, the tank shall be designated as a Rapid Generation Tank.
  - If radiolytic time to LFL < 7 days, the waste tank configuration must be changed to increase the waste tank radiolytic time to LFL to ≥ 7 days (e.g., lower HLLCP, reduce the tank supernate temperature, adjust tank chemistry, reduce SAV, reduce waste level). Once the option(s) is selected, go back to step a to re-calculate the waste tank times to LFL.
- If radiolytic time to LFL is a numeric value and spontaneous time to LFL is immediate, the waste tank flammability classification will be designated based on the radiolytic time to LFL. The Spontaneous Liberation Protection Program will protect the waste tank

vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification defined by the radiolytic time to LFL.

- If radiolytic time to LFL ≥ 28 days, the tank can be designated as a Slow or Rapid Generation Tank.
- If 7 days ≤ radiolytic time to LFL < 28 days, the tank shall be designated as a Rapid Generation Tank.
- If radiolytic time to LFL < 7 days, the waste tank configuration must be changed to increase the waste tank radiolytic time to LFL to ≥ 7 days (e.g., lower HLLCP, reduce the tank supernate temperature, adjust tank chemistry, reduce SAV, reduce waste level). Once the option(s) is selected, go back to step a to re-calculate the waste tank times to LFL.

- If both the radiolytic time to LFL and spontaneous time to LFL are numeric values, then the lower of the radiolytic time to LFL or the spontaneous time to LFL (named time to LFL below) will be used to determine the waste tank flammability classification.
  - If time to LFL ≥ 28 days, the tank can be designated as a Slow or Rapid Generation Tank.
  - If 7 days ≤ time to LFL < 28 days, the tank shall be designated as a Rapid Generation Tank.
  - If time to LFL < 7 days, then
    - If radiolytic time to LFL < 7 days, the waste tank configuration must be changed to increase the waste tank radiolytic time to LFL to ≥ 7 days (e.g., lower HLLCP, reduce the tank supernate temperature, adjust tank chemistry, reduce SAV, reduce waste level). Once the option(s) is selected, go back to step a to re-calculate the waste tank times to LFL. If the spontaneous time to LFL is also < 7 days, the Spontaneous Liberation Protection Program will protect the waste tank vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification defined by the radiolytic time to LFL.
    - If 7 days ≤ radiolytic time to LFL < 28 days, and spontaneous time to LFL< 7 days, the tank shall be designated as a Rapid Generation Tank. The Spontaneous Liberation Protection Program will protect the waste tank vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification defined by the radiolytic time to LFL.
    - If radiolytic time to LFL ≥ 28 days, and spontaneous time to LFL< 7 days, the tank can be designated as a Rapid or Slow Generation Tank. The Spontaneous Liberation Protection Program will protect the waste tank vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification.

4.1.2.4 IMPLEMENTATION ACTIONS

1. The waste tank flammability classification shall be determined using WCS [Ref. 11] or an engineering evaluation and shall be documented in the ERD. [TSR SAC 5.8.2.27.a]

2. The waste tank hydrogen concentration SAV (excluding Tank 50, Very Slow Generation Tanks, Closure Waste Tanks and Acidic Chemical Cleaning Mode Waste Tanks) shall be determined in WCS [Ref. 11] or an engineering evaluation. The TSR hydrogen concentration LFL limit shall be based on the hydrogen concentration SAV and account for

potential organics and instrument uncertainties and shall be documented in the ERD. [TSR SAC 5.8.2.27.b]

3. Liquid additions to a waste tank (e.g., water additions, waste transfers) shall be pre-evaluated to determine the impact on the hydrogen generation rate, time to LFL, and tank flammability classifications for the affected process areas (e.g., sending and receiving tanks) [TSR SAC 5.8.2.27.a].

4. If the evaluated activity results in a tank flammability classification change to a more restrictive status (SLOW to RAPID, VERY SLOW to RAPID, VERY SLOW to SLOW), then the status will be updated in the ERD and implemented in the facility via the ERD linking procedure [Ref. 55] prior to initiation of the planned activity. [TSR SAC 5.8.2.27.a]

5. If the projected radiolytic time to LFL results in less than seven days or the maximum hydrogen generation rate is exceeded, then the evaluated activity shall not be performed. [TSR SAC 5.8.2.27.c]

6. As a result of pre-transfer evaluation (e.g., transfers, sludge or salt removal) or a change in the waste tank configuration (e.g., chemistry, solids level), it may be necessary to change the HLLCP setpoint to protect the desired tank classification. In these cases, an engineering evaluation shall determine the new HLLCP setting, taking into account maximum missing waste, and instrument uncertainty. When the engineering evaluation requires lowering the HLLCP setpoint of a Type III/IIIA waste tank, additional consideration of the volume of contingency space should be applied (See Section 6.4). The HLLCP setpoint shall be updated in WCS [Ref. 11] and the ERD upon completion of the field work.

7. Ventilation is required on Very Slow Generation Tanks while receiving steam jetted transfers because of the potential of dissolved hydrogen contributions above the equilibrium resulting in greater than, or equal to, 100% of the LFL_{OC}. Operation of the exhaust fan shall be maintained for the duration of the transfer.

8. The Electronic Transfer Approval Form (ETAF) shall address ventilation system requirements during jetted transfer receipts for Very Slow Generation Tanks.

9. Periodically, the flammability classifications of all waste tanks will be reviewed to determine if any are at risk of an unexpected flammability classification change due to fluctuations in sample results. If a waste tank is identified by this review, recommendations (e.g., chemical additions, lowering probe heights, etc.) shall be provided to the facility to avoid this risk (See Section 6.2).

10. For Very Slow Generation Tanks not containing slurried sludge, the equilibrium flammable hydrogen concentration [H_{eq}] shall be calculated based on the vapor space volume protected by HLLCP, using WCS [Ref. 11] or an engineering evaluation. Those waste tanks with H_{eq} > 60% LFL_{OC} shall be identified in the ERD.

11. For Very Slow Generation Tanks containing slurried sludge, the equilibrium flammable hydrogen concentrations ([H_{eq}] and [H'_{eq}]) shall be calculated based on the vapor space volume protected by HLLCP and based on the actual/projected waste level, respectively,

using WCS [Ref. 11] or an engineering evaluation. Those waste tanks with H_{eq} > 60% OR (H'_{eq} + TG_{SS}) > 60% LFL_{OC} shall be identified in the ERD.

4.1.3 SEISMIC TIME TO LFL

4.1.3.1 SEISMIC TIME TO LFL METHODOLOGY

The methodology for determining the seismic time to LFL is consistent with the methodology presented in the Time to LFL Methodology (Section 4.1.2.2). This section provides all the equations used in determining the seismic time to LFL except those used in determining the temperature corrected hydrogen generation rate (Q_{H2}) and the volume fraction of hydrogen trapped in sludge and salt (H_{mix}), which can be found in Section 4.1.2.2.1 Variable Q_{H2} Calculation and in Section 4.1.2.2.2 Variable H_{mix} Calculation, respectively. Calculations of variables listed in this section are only applicable to this section unless otherwise noted. The waste tank seismic time to LFL can be determined using the following equation:

Eq. #36 Seismic Time to LFL =

$$\frac{-\ln\left[\dfrac{LFL_{OC} - \dfrac{Q_{H2}}{Q_{H2} + Q'_{ATM}}}{y_{0,seismic} - \dfrac{Q_{H2}}{Q_{H2} + Q'_{ATM}}}\right]}{\dfrac{Q_{H2} + Q'_{ATM}}{V'_v}}$$

Where:

Seismic Time to LFL	=	It is the time for the hydrogen concentration in the waste tank vapor space to go from $y_{0,seismic}$ to the LFL_{OC} following a seismic event
$y_{0,seismic}$	=	Initial hydrogen concentration in the waste tank vapor space following a seismic event, vol. frac. (see Variable $y_{0,seismic}$ Calculation)
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL (100% CLFL Tank 50) (see Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Variable Q_{H2} Calculation in Section 4.1.2.2.1)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q'_{ATM} Calculation)
V'_V	=	Vapor space volume based on actual/projected waste tank level, ft^3 (see Variable V'_v Calculation)

The seismic time to LFL calculated using Equation 36 may return an error, due to attempting to calculate the natural log of a negative number, or return a negative seismic time to LFL depending on the conditions of the indicated waste tank. The bullets below can be used to

determine the waste tank seismic time to LFL, if the waste tank conditions are met, prior to applying Equation 36 for seismic time to LFL calculation.

$\frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$ in Equation 36 is defined as H'_{eq} (see Variable H'_{eq} Calculation below). Substituting H'_{eq} for $\frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$ into Equation 36 yields

$$\text{Seismic Time to LFL} = \frac{-\ln\left[\frac{LFL_{OC} - H'_{eq}}{y_{0,seismic} - H'_{eq}}\right]}{\frac{Q_{H2} + Q'_{ATM}}{V'_V}}$$

- $H'_{eq} < LFL_{OC}$ and $H'_{eq} < y_{0,seismic}$
  - If $y_{0,seismic} < LFL_{OC}$, the waste tank vapor space never reaches flammable condition. The waste tank seismic time to LFL is infinite and Equation 36 is not required.
  - If $y_{0,seismic} \geq LFL_{OC}$, the waste tank seismic time to LFL is immediate and Equation 36 is not required.

- $H'_{eq} > LFL_{OC}$ and $H'_{eq} > y_{0,seismic}$
  - If $y_{0.seismic} < LFL_{OC}$, the waste tank seismic time to LFL can be determined using the methodology described in this section.
  - If $y_{0,seismic} \geq LFL_{OC}$, the waste tank seismic time to LFL is immediate and Equation 36 is not required.

- $H'_{eq} > LFL_{OC}$ and $H'_{eq} < y_{0,seismic}$
  Since $y_{0,seismic} > H'_{eq}$ and $H'_{eq} > LFL_{OC}$, $y_{0,seismic} > LFL_{OC}$. The waste tank seismic time to LFL is immediate and Equation 36 is not required.

- $H'_{eq} < LFL_{OC}$ and $H'_{eq} > y_{0,seismic}$
  Since $y_{0,seisimic} < H'_{eq}$ and $H'_{eq} < LFL_{OC}$, $y_{0,seismic} < LFL_{OC}$. The waste tank seismic time to LFL is infinite and Equation 36 is not required.

VARIABLE $y_{0,SEISMIC}$ CALCULATION – SEISMIC TIME TO LFL

The initial concentration used in the seismic time to LFL equation shall include the steady state hydrogen equilibrium concentration accounting for minimum ventilation, (except for Very Slow Generation Tanks, which shall assume the hydrogen equilibrium with atmospheric breathing) and the effects of post seismic trapped gas release. $y_{0,seismic}$ is then determined using the expression below.

Eq. #37 $$y_{0,seismic} = \text{Equil. Conc.} + \text{TG}$$

Where:

$y_{0,Seismic}$	=	Initial hydrogen concentration in the vapor space following a seismic event, vol. frac.
Equil. Conc	=	Initial hydrogen concentration in units of vol. frac. • Rapid or Slow Generation Tanks: higher of 2.5% of LFL_T (3.8% of LFL_T for Tank 50) (see Variable LFL_T Calculation), or steady state hydrogen equilibrium (see Variable H'_{eq} Calculation), accounting for the minimum DSA purge flow rate • Very Slow Generation Tanks: higher of 2.5% of LFL_T (3.8% of LFL_T for Tank 50) (see Variable LFL_T Calculation), or steady state hydrogen equilibrium concentration (see Variable H'_{eq} Calculation), accounting for atmospheric breathing
TG	=	Hydrogen concentration due to trapped gas release in units of vol. frac. H_2 (see Variable TG Calculation)

VARIABLE LFL_{OC} CALCULATION

- **Waste tanks excluding Tank 50:** The LFL, corrected for organic and temperature, is determined by using the Burgess – Wheeler correlation and subtracting the organic contribution, as follows:

Eq. #38 $$LFL_{OC} = LFL_{25C} \cdot [1 - A \cdot (T - 25)] - OC$$

Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
OC	=	The organic contribution equivalent hydrogen concentration (i.e., 5% of LFL_{25C} (0.002-volume fraction)), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^oC^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C [Refs. 1, 24]

- **Tank 50:** Due to the contribution of trace organics of up to 5% of the CLFL and Isopar of up to 51.2% of the CLFL, LFL_{OC} for Tank 50 at 100% of the CLFL is calculated to be 43.8% of the CLFL at 43°C or 43.8% of the LFL for hydrogen at 43°C [Ref. 24].

Eq. #39 $$LFL_{OC} = \frac{43.8}{100} \cdot LFL_{25C} \cdot [1 - A \cdot (43 - 25)]$$

Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$

VARIABLE LFL_T CALCULATION – SEISMIC TIME TO LFL

LFL for hydrogen can be corrected for temperature. Using the Burgess - Wheeler correlation, the temperature corrected LFL for hydrogen, LFL_T, is determined as follows:

Eq. #40 $$LFL_T = LFL_{25C} \cdot [1 - A \cdot (T - 25)]$$

Where:

LFL_T	=	LFL corrected for temperature, vol. frac.
LFL_{25C}	=	LFL at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C [Refs. 1, 24]

VARIABLE H'_{EQ} CALCULATION – SEISMIC TIME TO LFL

For Rapid and Slow Generation Tanks, steady state hydrogen equilibrium accounting for ventilation (minimum required purge flow for the applicable flammability classification) may be used as the assumed initial hydrogen concentration at the time of a seismic event. The steady state hydrogen equilibrium ($H_{eq\ (Rapid/Slow)}$) is calculated using the following equation:

Eq. #41 $$H_{eq\ (Rapid/\ Slow)} = \frac{Q_{H2}}{Q_{H2} + 60\,(Q_{purge})}$$

Where:

$H_{eq\ (Rapid/Slow)}$	=	Hydrogen concentration at equilibrium for Rapid and Slow Generation Tanks, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr. (see Variable Q_{H2} in Section 4.1.2.2.1)
Q_{purge}	=	Minimum purge flow rate, ft^3/min

= 72 ft^3/min for Rapid tanks

= 45 ft^3/min for Slow tanks

60 = Conversion factor from mins to hours

The $H_{eq\ (Rapid/Slow)}$ value is compared to 2.5% of the LFL_T (3.8% of the LFL_T for Tank 50) and the greater of the two is used as Equil. Conc. in Equation 37.

For Very Slow Generation Tanks, steady state hydrogen equilibrium accounting for atmospheric breathing may be used as the assumed initial hydrogen concentration at the time of a seismic event and is represented in the equation below:

Eq. #42 $$H'_{eq} = \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$$

Where:

H'_{eq}	=	Hydrogen concentration at equilibrium for Very Slow Generation Tanks, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} in Section 4.1.2.2.1)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q'_{ATM} Calculation)

The H'_{eq} value is compared to 2.5% of the LFL_T (3.8% of the LFL_T for Tank 50) and the greater of the two is used as Equil. Conc. in Equation 37.

VARIABLE Q'_{ATM} CALCULATION – SEISMIC TIME TO LFL

The atmospheric breathing assumptions and methodology are established in Reference 1 Section 3.4.1.5.5. The atmospheric breathing rate is determined as follows:

Eq. #43 $$Q'_{ATM} = \frac{\text{mean atm.fluctuation}}{1013} \cdot \frac{V'_v}{24}$$

Where:

Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr
Mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V'_v	=	Vapor space volume based on the actual/projected waste tank level, ft^3 (see Variable V'_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE TG CALCULATION – SEISMIC TIME TO LFL

The contribution of post seismic trapped gas released from saltcake, settled sludge, and slurried sludge is additive. The following equation is used to determine the vapor space hydrogen

concentration due to trapped gas release from each layer (i.e., saltcake, settled sludge, and slurried sludge) under post seismic conditions [Ref. 14]. Each contributing phase (i.e., trapped gas release from saltcake, trapped gas release from settled sludge, and trapped gas release from slurried sludge) shall have a separate value of trapped hydrogen gas released (TG) and these values are added together to determine the total seismic initial concentration:

Eq. #44 $$TG = \frac{V_{solids} \cdot G_s \cdot H_{mix} \cdot C \cdot F_R}{V'_v}$$

Where,

TG	=	Trapped hydrogen released during a seismic event, vol. frac.
V_{solids}	=	Volume of saltcake, slurried sludge or settled sludge in the tank that is available to liberate hydrogen, ft^3 (see Variable V_{SOLIDS} Calculation)
G_s	=	Fraction of trapped bubble gas, vol. frac. (see Variable G_s Calculation)
H_{mix}	=	Hydrogen fraction in trapped gas (see Section 4.1.2.2.2 Variable H_{mix} Calculation)
C	=	Pressure correction (see Variable C Calculation)
F_R	=	Trapped gas release fraction, vol. frac. (see Variable F_R Calculation)
V'_v	=	Vapor space volume using actual or projected waste level, ft^3 (see Variable V'_v Calculation)

VARIABLE V_{SOLIDS} CALCULATION – SEISMIC TIME TO LFL

All insoluble solids are considered to retain trapped gas for the purposes of trapped gas retention. The DSA, Section 3.4.1.5.3, establishes the following input for determining the volume of solids layers (i.e., saltcake, slurried sludge and settled sludge) affected due to seismic event. The volume of the solids layers is determined by multiplying the affected depth (in) by the applicable waste tank fill factor (gal/in).

- Saltcake
  - Waste tanks containing saltcake without free liquid above the salt layer
    - No trapped gas is released from salt
  - The saltcake depth/region that becomes mobilized during a seismic event and is available to liberate hydrogen is equal to the least of the following:
    - Depth of the saltcake
    - Depth of total overlying waste level (including settled sludge, slurried sludge, and supernate) above the saltcake
    - 40 inches

- Settled Sludge
  - The volume of settled sludge available to liberate hydrogen is equal to zero if the sludge contains an overlying saltcake layer greater than 40 inches.

- The volume of settled sludge available to liberate hydrogen following a seismic event is proportional to the height of the settled sludge layer and the overlying waste layer above it:

  $$\text{Settled sludge volume (gals)}.\frac{\text{Settled sludge layer (inches)+Total overlying waste layer(inches)}}{\text{400 inches}}$$

  Where: Total overlying waste level = Depth of total overlying waste level (including saltcake, slurried sludge, and supernate) above the settled sludge layer

  Saltcake below the settled sludge layer does not contribute to the total settled sludge volume.

- Slurried Sludge: The volume of slurried sludge that is available to liberate hydrogen is the entire slurried sludge volume in the waste tank.

VARIABLE G_S CALCULATION – SEISMIC TIME TO LFL

The DSA, Section 3.4.1.5.3, establishes the following input for determining the percentage of trapped bubble gas available to be released as follows:

- For waste tanks containing slurried sludge, the percentage of trapped bubble gas volume is 20% (0.20 volume fraction) of the volume of slurried sludge.

- For waste tanks containing settled sludge, the percentage of trapped bubble gas volume is 10% (0.10 volume fraction) of the volume of settled sludge.

- For waste tanks containing saltcake, the percentage of trapped bubble gas volume is 11% (0.11 volume fraction) of the volume of salt.

VARIABLE C CALCULATION – SEISMIC TIME TO LFL

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release due to agitation. The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #45 $$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X}\right) + \frac{1}{2}\frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers above the evaluated layer
ρ_a	=	Density of layer above the evaluated layer material, kg/m³
h_a	=	Height of layer above the evaluated layer, m
ρ_1	=	Density of the evaluated layer material, kg/m³
h_1	=	Height of the evaluated layer, m

g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325, Pa/atm

VARIABLE F_R CALCULATION – SEISMIC TIME TO LFL

The DSA, Section 3.4.1.5.3, establishes the following input for determining the trapped gas release percentage from each solids layer (i.e., saltcake, slurried sludge, and settled sludge) due to seismic event:

- Saltcake layer: 50% (0.50 volume fraction) of the trapped gas is released from the affected saltcake layer

- Slurried sludge layer: 100% (1.00 volume fraction) of the trapped gas is released from the affected slurried sludge layer within a waste tank (even if saltcake and/or settled sludge layers are present)

- Settled sludge layer: 50% (0.50 volume fraction) of the trapped gas is released from the affected settled sludge layer

The affected solids layer is defined in Section Variable V_{SOLIDS} Calculation.

VARIABLE V'_v CALCULATION – SEISMIC TIME TO LFL

The vapor space volume used to calculate the seismic time to LFL is based on the actual or projected waste level. The calculations account for the maximum missing waste volume when considering incoming transfers. The following equation is the vapor space volume calculation, in cubic feet:

Eq. #46 $$V'_v = 0.13368\ [V_T - (L_{tank}\ .\ Ff) - MMW]$$

Where,

V'_v	=	Vapor space volume using actual/projected waste tank level, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
L_{tank}	=	Actual or projected waste level, inches
0.13368	=	Conversion factor from gallons to ft^3
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Maximum missing waste volume, gallons (to be accounted for in the receipt tank for incoming transfers, see discussion below)

For waste tanks receiving transfers from a sending vessel greater than or equal to 15,000 gallons or has continuous makeup capability, MMW is equal to 15,000 gallons. If the sending vessel is less than 15,000 gallons and does not have continuous makeup capability, MMW is equal to the volume of the vessel. The liquid source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrical or

mechanically isolated. In lieu of using the actual/projected waste contents, the evaluation may be based upon the vapor space volume protected by the Tank Fill Limits Program. Liquid additions to the waste tank from DWS do not have continuous makeup capability.

4.1.3.2 IMPLEMENTATION ACTIONS

1. The seismic time to LFL shall be determined using WCS [Ref. 11] or an engineering evaluation. [TSR SAC 5.8.2.27.d, 5.8.2.27.e]

2. The emergency response priority classification (Priority 1 and Priority 2) shall be determined by the seismic time to LFL. Response priorities shall be, in the order of decreasing priority: Priority 1 Tanks (seismic time to LFL < 24 hours), Priority 2 Acidic Chemical Cleaning Tanks (tank primary, then annulus), then remaining Priority 2 Tanks (seismic time to LFL < 7 days).

3. Ensure that only 7 waste tanks can reach 100% of the LFL_{OC} in less than 24 hours assuming no ventilation and including the effects of post-seismic trapped gas release. Document these waste tanks as Priority 1 in the ERD [TSR SAC 5.8.2.27.d]

4. Ensure that only 14 waste tanks can reach 100% of the LFL_{OC} in less than 7 days including:
   - Effects of post-seismic trapped gas release, assuming no ventilation
   - Number of waste tanks in Acidic Chemical Cleaning Mode.

   Document these waste tanks as Priority 1 and Priority 2, as applicable, in the ERD [TSR SAC 5.8.2.27.e].

5. Liquid additions to a waste tank (e.g., water additions, waste transfers) shall be pre-evaluated to determine the impact on the seismic time to LFL for the affected waste tanks using WCS [Ref. 11] or an engineering evaluation. [TSR SAC 5.8.2.27.d, 5.8.2.27.e]

6. If the projected number of waste tanks capable of becoming flammable following a seismic event (including the effects of post seismic trapped gas release and number of waste tanks in Acidic Chemical Cleaning Mode) is greater than 7 Priority 1 tanks or a total of 14 Priority 1 and 2 tanks, then the evaluated activity shall not be performed. [TSR SAC 5.8.2.27.d, 5.8.2.27.e]

7. A path forward shall be provided to DOE (addressing the additional risk and recovery time) if a transfer required to mitigate a tank leak causes additional tanks (more than 14) to have the potential to become flammable in less than seven days. Because the transfer is mitigating a degraded condition (i.e., placing the facility in a safer condition), the path forward is not required to be provided to DOE prior to initiating the transfer. [TSR AC 5.8.2.27.f]

4.2 QUIESCENT TIME

4.2.1 QUIESCENT TIME PROGRAM

4.2.1.1 BACKGROUND

The Quiescent Time Program does not apply to Type I/II Acidic Chemical Cleaning Waste Tanks or Closure Waste Tanks. The Quiescent Time Program is applicable to waste tanks that contain slurried sludge. The program is also applicable to waste tanks that contain settled sludge, if the waste tank was placed under the Seismic Release Protection portion of the Quiescent Time Program. Depending on whether the waste tank has completed full sludge inventory initial trapped gas depletion via mixing operations or contains a partial layer of slurried sludge as a direct result of sludge agitation via waste tank mixing devices or receipt of slurried sludge via a transfer, the Waste Tank Quiescent Time Program is divided into two sub-programs: Seismic Release Protection and Spontaneous Liberation Protection [Ref. 1].

- **Seismic Release Protection Program** – The Seismic Release Protection Program protects the waste tank vapor space from reaching 100% LFL in less than 7 days following a seismic event. Waste tanks will be placed under the Seismic Release Protection Program after successful initial full inventory sludge mixing (i.e., hydrogen depletion). Initial full inventory sludge mixing is achieved upon completion of an adequate number of fully inserted waste tank mixing devices operating (with the turntable operating) for a cumulative period of 10 days. The criteria are also applied to waste tanks that contain a saltcake layer beneath the sludge layer. In this case, the saltcake level is used in determining the depth of the fully inserted waste tank mixing devices. Additionally, waste tanks containing no sludge (even if saltcake is present) will be placed under the program after receiving slurried sludge via a transfer.

  Once placed under the Seismic Release Protection, the waste tanks will remain in the program even if the slurried sludge in the waste tanks becomes settled sludge after meeting the settled sludge criteria (see Section 3.0). The waste tanks may exit the program only when the program is no longer applicable due to waste tank conditions (e.g., waste tanks entering Chemical Cleaning Mode [Type I/II Acidic Chemical Cleaning Waste Tanks], or Closure Mode [Closure Waste Tanks], waste tanks with all settled sludge/slurried sludge layers removed).

- **Spontaneous Liberation Protection Program** – The Spontaneous Liberation Protection Program protects the waste tank vapor space from reaching 100% LFL in less than the time protected by the waste tank flammability classification, following a spontaneous release event. Waste tanks will be placed under the Spontaneous Liberation Protection Program when the waste tanks contain a slurried sludge layer as a direct result of sludge agitation via waste tank mixing devices or receipt of slurried sludge via a transfer (including waste tanks in the Seismic Release Protection Program).

  Waste tanks placed under the Spontaneous Liberation Protection Program will remain in the program until the program is no longer applicable due to waste tank conditions (e.g., waste tanks entering Chemical Cleaning Mode [Type I/II Acidic Chemical Cleaning Waste Tanks]

or Closure Mode [Closure Waste Tanks], slurried sludge layer becomes settled sludge, slurried sludge layers removed). Waste tanks may be removed from the Spontaneous Liberation Protection Program if the slurried sludge in the waste tanks becomes settled sludge after meeting the settled sludge criteria (see Section 3.0).

The Waste Tank Quiescent Time Program shall require the following to protect assumed times to LFL (CLFL for Tank 50) excluding waste tanks in Acidic Chemical Cleaning Mode or Closure Mode:

- Determine and track waste tanks required to be in the Waste Tank Quiescent Time Program and document in the ERD (N-ESR-G-00001). [TSR SAC 5.8.2.28.a]

- Waste tanks under the Seismic Release Protection Program shall be controlled to ensure that the waste tanks will not reach 100% of the LFL (CLFL for Tank 50) (due to trapped gas release from the settled sludge/slurried sludge and subsequent radiolytic hydrogen production) in less than 7 days following a seismic event. [TSR SAC 5.8.2.28.b]

- Waste tanks under the Spontaneous Liberation Protection Program shall be controlled to ensure that the minimum time to LFL (CLFL for Tank 50) is maintained defined by the waste tank flammability classification (see Section 4.1.2.1). [TSR SAC 5.8.2.28.c]

Waste tanks are controlled to ensure the applicable criteria discussed above are not exceeded, by one or both of the following methods [Ref. 1]:

- Periodically operate waste tank mixing devices in the applicable sludge layer to limit the amount of trapped gas that can be released.

- Maintain waste tank configuration (e.g., waste level, slurried sludge level) to limit the amount of trapped gas that can be released and ensure adequate waste tank vapor space volume.

An integral part of the Quiescent Time Program (i.e., Seismic Release Protection Program and Spontaneous Liberation Protection Program) is to determine the maximum time that the applicable settled/slurried sludge can remain undisturbed and still not retain sufficient hydrogen to cause the tank vapor space to exceed the applicable criteria if a hydrogen release event were to occur (e.g., earthquake). The maximum time, referred to as the quiescent time, is calculated based upon the following conservative inputs [Ref. 1]:

- The quiescent time starts from the end of the last successful hydrogen depletion operation (waste tank mixing device operation) or the time that the program became applicable to the start of the next hydrogen depletion operation.

  For waste tanks that receive transfers of slurried sludge that causes the waste tank to be placed in the Spontaneous Liberation Protection Program and/or Seismic Release Protection Program, the quiescent time starts at the end of the transfer.

For waste tanks that are undergoing initial sludge agitation using waste tank mixing devices (Spontaneous Liberation Protection), the quiescent time starts from the end of successful sludge agitation for an affected sludge layer. Successful sludge agitation occurs upon completion of an adequate number of waste tank mixing devices operating within acceptable times/speeds (with the turntable operating) for a cumulative period of 10 days. At this point the affected sludge layer within the zone of influence of the waste tank mixing devices (i.e., based on tank cross sectional area and sludge disturbance depth) is considered slurried sludge. If sludge agitation is stopped prior to completion of successful sludge agitation, the sludge is still considered settled sludge. If any waste tank mixing device is lowered, the affected sludge layer within the zone of influence of the waste tank mixing devices (based on the mixing device location prior to lowering) shall be considered slurried sludge [Ref. 1].

- The quiescent time is the allowable time between waste tank mixing device operation such that the hydrogen released from the applicable settled sludge/slurried sludge does not cause the tank vapor space to exceed the following criteria:

  - For Seismic Release Protection Program
    - Reach LFL_{OC} in less than 7 days following a seismic event (due to trapped gas release from the settled sludge /slurried sludge and subsequent radiolytic hydrogen production).

  - For Spontaneous Liberation Protection Program
    - Reach LFL_{OC} in less than 7 days for Rapid Generation Tanks (due to Isopar® L (Tank 50 only), trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation).
    - Reach LFL_{OC} in less than 28 days for Slow Generation Tanks (due to Isopar® L (Tank 50 only), trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation).
    - Reach LFL_{OC} for Very Slow Generation Tanks (due to Isopar® L (Tank 50 only), trace organics, trapped gas release from slurried sludge, and radiolytic hydrogen generation).

Trapped gas release is only considered from the applicable sludge layers (i.e., settled sludge/slurried sludge for Seismic Release Protection; slurried sludge for Spontaneous Liberation Protection). Other solids layers above (e.g., saltcake), or below (saltcake and/or settled sludge) the applicable sludge layer are not controlled as part of the Quiescent Time Program. The solids layers will be considered in determining/tracking the post-seismic trapped gas release seismic time to LFL (Section 4.1.3)

After successfully slurrying the entire sludge layer or entire tank contents, the Quiescent Time Program becomes applicable to that tank. Following the initial trapped gas depletion (via mixing operations), hydrogen depletion for the affected slurried sludge layer can be declared to be successful for a given tank quadrant if adequate mixing occurs.

- For Tank 50, Reference 52 demonstrates that adequate solids mixing of the tank occurs after successful completion of a 4-hour pump run at maximum allowable speed with three slurry pumps (assuming of two of the three pumps are the quad-volute slurry pumps and the Tank

50 solids content is less than or equal to 20 wt%). Reference 52 also demonstrates that a single slurry pump (standard or quad-volute) is capable of depleting approximately 33% of the retained hydrogen inventory in the tank. The effect of a non-operational pump is that it could leave up to 33% of the tank contents inadequately mixed, retaining the trapped gas inventory.

- For the remaining waste tanks, operational experiences and analysis performed in Reference 49 for CSMPs have demonstrated that adequate mixing occurs after successful completion of an 8 hour slurry pump/CSMP operation at maximum allowable speed with evidence of adequate sludge mixing (e.g., camera inspection, motor loading within acceptable ranges). For a waste tank, it has been demonstrated that a single slurry pump/CSMP is capable of depleting at least 25% of the retained hydrogen inventory in the waste tank or slurried sludge layer. Thus, the trapped gas inventory can be removed with four slurry pumps/CSMPs operating in a manner that ensures adequate mixing. Likewise, the effect of a non-operational pump is that it could leave up to 25% of the tank content inadequately mixed, retaining the trapped gas inventory. Information on CSMP flow rates and the calculated effective cleaning radius is provided in Reference 49. Reference 22 demonstrates that a single SMP operated for an 8-hour period at maximum allowable speed theoretically has sufficient mixing capability to deplete at least 50% of the retained hydrogen inventory in the tank or slurried sludge layer. Depending on waste tank type and SMP riser location, the trapped gas inventory in the tank or slurried sludge layer can be removed by two or three SMPs operating in a manner that ensures adequate mixing [Ref. 22]. The effect of a non-operational SMP is that it could leave up to 50% of the tank or slurried sludge layer contents inadequately mixed, retaining trapped gas inventory (regardless of whether two or three SMPs are required for 100% depletion).

- There have been no operational experiences or studies to determine when adequate mixing occurs after completion of an SBP run. Therefore, operation of the SBPs cannot be used to credit any DSA or non-DSA defined Quiescent Times.

- Empirical trapped gas release data from the tank under consideration or an engineering evaluation utilizing effective cleaning radius may be evaluated to permit operation other than that described above and still claim adequate mixing occurs to deplete the trapped hydrogen inventory in the tank or slurried sludge layer.

It is recognized under certain waste tank conditions during a process upset associated with typical initial sludge agitation processing plans, only a portion of the sludge layer may become slurried sludge within a waste tank. Additionally, cases could occur where the entire sludge layer may not be actually mixed (e.g., due to limited number of waste tank mixing devices operated in the sludge layer), but the layer is considered slurried sludge based on the discussion in Section 3.0 and inputs in Section 4.3.2.2 for sludge agitation. For example, operation of only one SMP (or two slurry pumps/SBPs/CSMPs) for a cumulative period of 10 days is assumed to cause the entire sludge layer (100% cross sectional area) to become slurried sludge. However, the entire sludge layer would not actually be mixed as the settled sludge agitation input is a conservative maximum value for sludge disturbance. The requirements for declaring hydrogen depletion success (stated above), assume an entire layer or entire tank contain slurried sludge (or contain sludge that was actually mixed) and would not be applicable to these scenarios. Should this

situation occur (where only a portion of a sludge layer is considered slurried sludge or a portion of the sludge layer is actually mixed), an engineering evaluation shall be completed to determine the requirements for hydrogen depletion for this waste tank. The evaluation shall consider the location of the waste tank mixing device(s) used for hydrogen depletion in relationship to the area of slurried sludge (or portion of the sludge layer that is actually mixed), and determine the resulting trapped gas depletion/retention percentage.

Tank 26 waste removal performed its first CSMP mixing campaign in February 2019. A sludge sounding performed following a 10-day mixing campaign of all four CSMPs indicated the sludge was disturbed lower in the tank than was expected (i.e., a 32.4-inch disturbance depth versus the 24-inch DSA disturbance depth input). A review of Tank 26 process history indicated that the tank served as the 242-16F evaporator feed tank and canyon receipt tank, having a history of containing highly concentrated supernate, resulting in a waste layer containing a mixture of salt and sludge [Ref. 60, Action 4]. For waste tanks with the potential to contain inter-mixed sludge/salt waste layers, the more conservative waste layer should be assumed for gas release and quiescent time evaluations **[Ref. 61]**.

4.2.1.2 QUIESCENT TIME PROGRAM METHODOLOGY

The initial hydrogen concentration, y_0, shall be 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or steady state hydrogen equilibrium accounting for atmospheric breathing using the actual vapor space volume (H'_{eq}) for Very Slow Generation Tanks. Use of the initial hydrogen concentration is considered acceptable for Seismic Release or Spontaneous Liberation Protection due to the following:

- For waste tanks which require continuous waste tank ventilation (i.e., Rapid and Slow Generation Tanks), the ventilation system is adequate to maintain the radiolytic hydrogen concentration less than 25% of the LFL_T.

- For waste tanks which do not require continuous waste tank ventilation (i.e., Very Slow Generation Tanks), the initial hydrogen concentration may exceed 25% of the LFL_T. Use of the higher of 25% of the LFL_T (3.8% LFL_T for Tank 50) or steady state hydrogen equilibrium accounting for atmospheric breathing using the actual vapor space volume is needed to protect the assumed initial hydrogen concentration for the waste tanks

The initial hydrogen concentration (y_0) is added to the trapped gas contribution (TG) from the applicable sludge layer(s) to determine the post seismic initial hydrogen concentration, y_0 (Seismic).

Eq. #47 $$y_o(\text{Seismic}) = y_o + TG$$

4.2.1.2.1 SEISMIC RELEASE PROTECTION

Upon depletion of the hydrogen inventory due to pump agitation, the trapped hydrogen gas inventory retained in the slurried sludge is a function of time (i.e., at time equal zero, the trapped gas inventory equals zero) until the maximum retained hydrogen value is reached. The trapped gas release during a seismic event for calculation of Seismic Quiescent Time is a summation of the retained hydrogen in the slurried sludge and in any settled sludge. Trapped gas release from

saltcake is not considered in calculation of the Seismic Quiescent Time as the contribution from saltcake is covered in calculation of the seismic time to LFL. If a Seismic Quiescent Time is required, and thus requires waste tank mixing devices to be run, the Seismic Quiescent Time only considers hydrogen depletion to occur in the slurried sludge layer. If additional solids layers will be impacted by the pump run, the additional trapped hydrogen release must be considered in an associated gas release evaluation. Equations/variables provided in this section are only applicable to this section unless otherwise noted.

The waste tank will require a Seismic Quiescent Time if y_0(Seismic) ≥ LFL_{OC}. From Equation 47, y_0(Seismic) is defined as the summation of the initial hydrogen concentration plus the trapped hydrogen gas released from the settled sludge and slurried sludge layer. Therefore, the Seismic Quiescent Time is required for the waste tank if

$$y_o + \mathrm{TG_{settled}} + \mathrm{TG_{slurried}} \geq \mathrm{LFL_{OC}} \text{ or}$$

Eq. #48 $$y_o + \frac{\mathrm{H_{mix}}}{V'_V} . [(\mathrm{V_{solids}} . \mathrm{G_s} . \mathrm{C} . \mathrm{F_R})_{settled} + (\mathrm{V_{solids}} . \mathrm{G_s} . \mathrm{C} . \mathrm{F_R})_{slurried}] \geq \mathrm{LFL_{OC}}$$

Where:

LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Variable LFL_{OC} Calculation)
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks, vol. frac. For H'_{eq}, see Variable H'_{eq} Calculation
H_{mix}	=	Fraction of hydrogen in trapped gas, determined using equations in Section 4.1.2.2.2 Variable H_{mix} Calculation
G_s	=	Fraction of trapped bubble gas (see Variable G_S calculation)
V_{solids}	=	Volume of settled sludge/slurried sludge in the tank that is available to liberate hydrogen, ft^3 (see Variable V_{solids} Calculation)
F_R	=	Fraction of trapped gas release from slurried/settled sludge (see Variable F_R Calculation)
C	=	Pressure correction (see Variable C Calculation)
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3 (see Variable V'_V Calculation)

Equation 51, 52, 53 or 54 will be used to calculate the Seismic Quiescent Time as applicable.

If y_0(Seismic) < LFL_{OC}, the following two bullets may be used to determine whether the waste tank Seismic Quiescent Time will be infinite.

The waste tank Seismic Quiescent Time will become infinite if one of the criteria below is met:

- The waste tank vapor space never becomes flammable (i.e., hydrogen concentration at equilibrium plus retained hydrogen gas released from slurried sludge/settled sludge is less than LFL_{OC}).

$$H'_{eq} + TG_{settled} + TG_{slurried} < LFL_{OC} \text{ or}$$

Eq. #49 $$\frac{Q_{H_2}}{Q_{H_2}+Q'_{ATM}} + \frac{H_{mix}}{V'_V}.[(V_{solids}.G_s.C.F_R)_{settled} + (V_{solids}.G_s.C.F_R)_{slurried}] < LFL_{OC}$$

Where:

LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft³/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q'_{ATM} Calculation)
H_{mix}	=	Fraction of hydrogen in trapped gas, determined using equations in Section 4.1.2.2.2 Variable H_{mix} Calculation
G_s	=	Fraction of trapped bubble gas (see Variable G_S calculation)
V_{solids}	=	Volume of settled sludge/slurried sludge in the tank that is available to liberate hydrogen, ft³ (see Variable V_{solids} Calculation)
F_R	=	Fraction of trapped gas release from slurried/settled sludge (see Variable F_R Calculation)
C	=	Pressure correction (see Variable C Calculation)
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3 (see Variable V'_V Calculation)

- The time it takes for the hydrogen concentration (including assumed initial hydrogen concentration plus retained hydrogen released from settled sludge/slurried sludge) in the waste tank vapor space to reach LFL_{OC} is greater than or equal to 7 days.

Eq. #50 $$\frac{-\ln\left[\frac{LFL_{OC}-\frac{Q_{H_2}}{Q_{H_2}+Q'_{ATM}}}{y_0+\frac{H_{mix}}{V'_V}.[(V_{solids}.G_s.C.F_R)_{settled}+(V_{solids}.G_s.C.F_R)_{slurried}]-\frac{Q_{H_2}}{Q_{H_2}+Q'_{ATM}}}\right]}{\frac{Q_{H_2}+Q'_{ATM}}{V'_V}} \geq (7).(24)$$

Where:

LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft³/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr, (see Variable Q'_{ATM} Calculation)
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac.
H_{mix}	=	Fraction of hydrogen in trapped gas, determined using equations in Section 4.1.2.2.2 Variable H_{mix} Calculation
G_s	=	Fraction of trapped bubble gas (see Variable G_S calculation)

V_{solids}	=	Volume of settled sludge/slurried sludge in the tank that are available to liberate hydrogen, ft^3 (see Variable V_{solids} Calculation)
F_R	=	Fraction of trapped gas release from slurried/settled sludge (see Variable F_R Calculation)
C	=	Pressure correction (see Variable C Calculation)
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3 (see Variable V'_V Calculation)
7	=	Minimum time between waste tank mixing device operation such that the waste tank vapor space will not become flammable, days
24	=	Conversion factor from hours to days

If none of the criteria above is met, the waste tank Seismic Quiescent Time is required. The Seismic Quiescent Time equation is derived as below.

- Waste tank with $\mathbf{H'_{eq} \geq LFL_{OC}}$ (H'_{eq}: hydrogen concentration at equilibrium [for calculation, see Variable H'_{eq} Calculation]; LFL_{OC}: temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. [for calculation, see Variable LFL_{OC} Calculation])

  The time dependence of the trapped hydrogen inventory for slurried sludge is demonstrated below:

$$G_s \,.\, H_{mix} \,.\, \mathrm{C} = \frac{\frac{H_R}{100} \,.\, Q_{H_2} \,.\, t}{V_{solids}}$$

  The trapped gas contribution is then calculated by substituting the hydrogen inventory, ($G_s \cdot H_{mix} \cdot C$) into Equation 44 to yield:

$$TG_{slurried} = \frac{V_{solids} \cdot \frac{\frac{H_R}{100} \,.\, Q_{H_2} \,.\, t}{V_{solids}} \,.\, F_R}{V'_V}$$

  The equation is then simplified and becomes the below equation.

$$TG_{slurried} = \frac{\frac{H_R}{100} \,.\, Q_{H_2} \,.\, F_R \,.\, t}{V'_V}$$

  Where:

$TG_{slurried}$	=	Volume fraction of hydrogen retained in slurried sludge, vol. frac
t	=	Time trapped gas retained in slurried sludge since the last hydrogen depletion, hours
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr
H_R	=	Percentage of hydrogen generated that is retained in slurried sludge

F_R	=	Fraction of trapped gas release from slurried sludge
V'_v		Vapor space volume using actual or projected waste tank level, ft^3

If the waste tank contains a settled sludge layer, the amount of hydrogen gas released from the settled sludge during a seismic event is:

$$TG_{settled} = \frac{V_{solids} \cdot G_s \cdot H_{mix} \cdot C \cdot F_R}{V'_V}$$

Where:

$TG_{settled}$	=	Hydrogen released from settled during a seismic event, vol. frac.
V_{solids}	=	Volume of settled sludge in the tank that is available to liberate hydrogen, ft^3
G_s	=	Fraction of trapped bubble gas, vol. frac.
H_{mix}	=	Hydrogen fraction in trapped gas
C	=	Pressure correction
F_R	=	Fraction of trapped gas release from settled sludge
V'_v	=	Vapor space volume using actual or projected waste level, ft^3

Substituting the slurried sludge and settled sludge trapped gas equations to the post seismic initial hydrogen concentration equation (Equation 47), y_0(Seismic), yields:

$$y_o(\text{Seismic}) = y_o + TG_{slurried} + TG_{settled} = y_o + \frac{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot F_R \cdot t}{V'_V} + \frac{V_{solids} \cdot G_s \cdot H_{mix} \cdot C \cdot F_R}{V'_V}$$

Where:

y_0(Seismic)	=	Post seismic initial hydrogen concentration, vol. frac.
y_0	=	Initial hydrogen concentration, vol. frac., 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) and for H'_{eq} Very Slow Generation Tanks)

y_0(Seismic) is then substituted into the time to LFL equation (Equation 1 in Section 4.1.2.2). To ensure the waste tank vapor space does not reach the LFL_{OC} less than 7 days (due to trapped hydrogen release), the waste tank time to LFL shall be at least 7 days.

$$\text{Time to LFL} = \frac{-\ln\left[\dfrac{LFL_{oc} - \dfrac{Q_{H_2}}{Q_{H_2} + Q'_{ATM}}}{y_o + \dfrac{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot F_{R,slurried} \cdot t}{V'_V} + \dfrac{V_{solids} \cdot G_s \cdot H_{mix} \cdot C \cdot F_{R,settled}}{V'_V} - \dfrac{Q_{H_2}}{Q_{H_2} + Q'_{ATM}}}\right]}{\dfrac{Q_{H_2} + Q'_{ATM}}{V'_V}} = 7 \text{ days} \cdot \frac{24 \text{ hrs}}{1 \text{ day}}$$

Rearranging the equation to solve for quiescent time, $t_{seismic}$ (t in equation above becomes $t_{seismic}$) for waste tanks containing slurried sludge and settled sludge layers, yields:

Eq. #51

$$t_{seismic} = \frac{1}{24} \cdot \frac{V'_V}{\frac{H_R}{100} \cdot Q_{H2} \cdot F_{R,slurried}} \cdot \left(\frac{LFL_{OC} - \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}}{e^{-(7)\,(24)\left(\frac{Q_{H2} + Q'_{ATM}}{V'_V}\right)}} - y_0 - \frac{V_{solids} \cdot G_s \cdot H_{mix} \cdot C \cdot F_{R,settled}}{V'_V} + \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}} \right)$$

If the waste tank contains slurried sludge but no settled sludge layer, $t_{seismic}$ becomes:

Eq. #52

$$t_{seismic} = \frac{1}{24} \cdot \frac{V'_V}{\frac{H_R}{100} \cdot Q_{H2} \cdot F_{R,slurried}} \cdot \left(\frac{LFL_{OC} - \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}}{e^{-(7)\,(24)\left(\frac{Q_{H2} + Q'_{ATM}}{V'_V}\right)}} - y_0 + \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}} \right)$$

Where:

$t_{seismic}$	=	Seismic Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft³/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
Q'_{ATM}	=	Atmospheric breathing rate, ft³/hr, (see Variable Q'_{ATM} Calculation)
H_{mix}	=	Fraction of hydrogen in trapped gas, determined using equations in Section 4.1.2.2.2 Variable H_{mix} Calculation
G_s	=	Fraction of trapped bubble gas (see Variable G_S calculation)
V_{solids}	=	Volume of settled sludge in the tank that is available to liberate hydrogen, ft³ (see Variable V_{solids} Calculation)
$F_{R,slurried}$	=	Fraction of trapped gas release from slurried sludge (see Variable F_R calculation)
$F_{R,settled}$	=	Fraction of trapped gas release from settled sludge (see Variable F_R calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Variable H_R Calculation)
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac. For H'_{eq} calculation, see Variable H'_{eq} Calculation
V'_v	=	Vapor space volume using actual or projected waste tank level, ft³, (see Variable V'_v Calculation)
7	=	Minimum time between waste tank mixing device operation such that the waste tank vapor space will not become flammable, days

24	=	Conversion factor from hours to days
C	=	Pressure correction (see Variable C Calculation)

- **Waste tanks with $H'_{eq} < LFL_{OC}$ (**H'_{eq}: hydrogen concentration at equilibrium [for calculation, see Variable H'_{eq} Calculation]; LFL_{OC}: temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. [for calculation, see Variable LFL_{OC} Calculation])

  The time dependence of the trapped gas inventory in the slurried and settled sludge to reach LFL_{OC} when the waste tank contains both the slurried and settled sludge layers is displayed in the expression below.

$$y_o(\text{Seismic}) = y_o + TG_{slurried} + TG_{settled} = y_o + \frac{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot t \cdot F_{R,slurried}}{V'_V} + \frac{V_{solids} \cdot G_S \cdot H_{mix} \cdot C \cdot F_{R,settled}}{V'_V} = LFL_{OC}$$

Where:

y_0(Seismic)	=	Post seismic initial hydrogen concentration, vol. frac.
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac.
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr
t	=	Time trapped gas retained in slurried/settled sludge since the last hydrogen depletion, hours
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3
V_{solids}	=	Volume of settled sludge that is available to liberate hydrogen, ft^3
G_S	=	Fraction of trapped bubble gas, vol. frac.
H_{mix}	=	Fraction of hydrogen in trapped gas
C	=	Pressure correction
$F_{R,slurried}$	=	Fraction of trapped gas release from slurried sludge
$F_{R,settled}$	=	Fraction of trapped gas release from settled sludge
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac.

To calculate the Seismic Quiescent Time, $t_{seismic}$, for waste tanks containing slurried sludge and settled sludge, the above equation is rearranged to solve for t and becomes Equation 53.

Eq. #53 $$t_{seismic} = \frac{1}{24} \cdot \frac{V'_V}{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot F_{R,slurried}} \cdot \left(LFL_{OC} - y_0 - \frac{V_{solids} \cdot G_S \cdot H_{mix} \cdot C \cdot F_{R,settled}}{V'_V}\right)$$

Where:

$t_{seismic}$	=	Seismic Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Variable LFL_{OC} Calculation)
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac. For LFL_T and H'_{eq} calculations, see Variable LFL_T Calculation and Variable H'_{eq} Calculation, respectively
V_{solids}	=	Volume of settled sludge that is available to liberate hydrogen, ft^3 (see Variable V_{solids} Calculation)
G_S	=	Fraction of trapped bubble gas, vol. frac. (see Variable G_S Calculation)
H_{mix}	=	Fraction of hydrogen in trapped gas, determined using equations in Section 4.1.2.2.2 Variable H_{mix} Calculation
C	=	Pressure correction (see Variable C Calculation)
$F_{R,slurried}$	=	Fraction of trapped gas release from slurried sludge (see Variable F_R Calculation)
$F_{R,settled}$	=	Fraction of trapped gas release from settled sludge (see Variable F_R Calculation)
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3 (see Variable V'_V Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Variable H_R Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
24	=	Conversion factor from hours to days

For waste tanks containing slurried sludge but no settled sludge layer, the Seismic Quiescent Time is calculated using Equation 54.

Eq. #54 $$t_{seismic} = \frac{1}{24} \cdot \frac{V'_V}{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot F_{R,slurried}} \cdot (LFL_{OC} - y_0)$$

Where:

$t_{seismic}$	=	Seismic Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL for all waste tanks, vol. frac. (see Variable LFL_{OC} Calculation)

y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac. For LFL_T and H'_{eq} calculations, see Variable LFL_T Calculation and Variable H'_{eq} Calculation, respectively
V'_v	=	Vapor space volume using actual or projected waste tank level, ft³ (see Variable V'_V Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Variable H_R Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft³/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
$F_{R,slurried}$	=	Fraction of trapped gas release from slurried sludge (see Variable F_R Calculation)
24	=	Conversion factor from hours to days

When the number of waste tank mixing devices available to liberate the retained trapped gas is less than the number of waste tank mixing devices required (e.g., only 3 slurry pumps instead of 4 slurry pumps), the generic methodology defined in Reference 45 can be used to calculate the adjusted Seismic Quiescent Time.

VARIABLE LFL_{OC} CALCULATION – QUIESCENT TIME PROGRAM

- **Waste tanks excluding Tank 50**

The temperature and organic corrected hydrogen concentration at 100% LFL is calculated as follows:

Eq. #55 $$LFL_{OC} = LFL_{25C} \cdot [1 - A \cdot (T - 25)] - OC$$

Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
OC	=	The organic contribution equivalent hydrogen concentration (i.e., 5% of LFL_{25C} (0.002-volume fraction)), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^oC^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C

- **Tank 50:** Due to the contribution of trace organics of up to 5% of the CLFL, Isopar of up to 51.2% of the CLFL, LFL_{OC} for Tank 50 at 100% of the CLFL is calculated to be 43.8% of the LFL at 43°C [Ref. 24]. Therefore, the LFL_{OC} is calculated using the equation below:

Eq. #56 $$LFL_{OC} = \frac{43.8}{100} \cdot LFL_{25C} \cdot [1 - A \cdot (43 - 25)]$$

Where:

LFL_{OC}	=	LFL for hydrogen corrected for organic contribution and temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$

VARIABLE LFL_T CALCULATION – QUIESCENT TIME PROGRAM

LFL for hydrogen can be corrected for temperature. Using the Burgess - Wheeler correlation, the temperature corrected LFL for hydrogen, LFL_T, is determined as follows:

Eq. #57 $$LFL_T = LFL_{25C} \cdot [1 - A \cdot (T - 25)]$$

Where:

LFL_T	=	LFL for hydrogen corrected for temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^{o}C^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C [Refs. 1, 24]

VARIABLE Q'_{ATM} CALCULATION – QUIESCENT TIME PROGRAM

The atmospheric breathing assumptions and methodology are established in Reference 1 Section 3.4.1.5.5. The atmospheric breathing rate is determined as follows:

Eq. #58 $$Q'_{ATM} = \frac{\text{mean atm.fluctuation}}{1013} * \frac{V'_V}{24}$$

Where:

Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr
Mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V'_V	=	Vapor space volume, ft^3, based on the actual/projected waste tank level (see Variable V'_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE H'_{EQ} CALCULATION – QUIESCENT TIME PROGRAM

The steady state hydrogen equilibrium accounting for atmospheric breathing using the actual vapor space volume can be calculated using the equation below.

Eq. #59 $$H'_{eq} = \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$$

Where:

H'_{eq}	=	Hydrogen concentration at equilibrium for Very Slow Generation Tanks, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} in Section 4.1.2.2.1)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q'_{ATM} Calculation)

VARIABLE V'_V CALCULATION – QUIESCENT TIME PROGRAM

The vapor space volume is based on the actual or projected waste level. The calculations account for the maximum missing waste volume when considering incoming transfers. The following equation is the vapor space volume calculation, in cubic feet:

Eq. #60 $$V'_v = 0.13368\ [V_T - (L_{tank} \cdot Ff) - MMW]$$

Where:

V'_V	=	Vapor space volume based on the actual/projected waste tank level, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
L_{tank}	=	Actual or projected waste level, inches
0.13368	=	Conversion factor from gallons to ft^3
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Maximum missing waste volume, gallons (to be accounted for in the receipt tank for incoming transfers, see discussion below)

For waste tanks receiving transfers from a sending vessel greater than or equal to 15,000 gallons or has continuous makeup capability, MMW is equal to 15,000 gallons. If the sending vessel is less than 15,000 gallons and does not have continuous makeup capability, MMW is equal to the volume of the vessel. The liquid source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrical or mechanically isolated. In lieu of using the actual/projected waste contents, the evaluation may be based upon the vapor space volume protected by the Tank Fill Limits Program. Liquid additions to the waste tank from DWS do not have continuous makeup capability.

VARIABLE C CALCULATION – QUIESCENT TIME PROGRAM

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release due to agitation. The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #61
$$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X} \right) + \frac{1}{2} \frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers above the evaluated settled/slurried sludge layer
ρ_a	=	Density of layer material above the evaluated settled/slurried sludge layer, kg/m³
ρ_1	=	Density of the evaluated settled/slurried sludge material, kg/m³
h_a	=	Height of layer above the evaluated settled/slurried sludge layer, m
h_1	=	Height of the evaluated settled/slurried sludge layer, m
g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325, Pa/atm

VARIABLE H_R CALCULATION – QUIESCENT TIME PROGRAM

The percentage of hydrogen generated that is retained in the slurried sludge (H_R) is based on the depth of the slurried sludge (until the maximum retained hydrogen value is reached as determined using the maximum trapped bubble gas volume and associated hydrogen percent in trapped gas).

- If the slurried sludge depth is less than 40 inches, 25% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 40 inches and less than 90 inches, 50% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 90 inches and less than 110 inches, 75% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 110 inches, 100% of the hydrogen generated is retained.

VARIABLE F_R CALCULATION – SEISMIC QUIESCENT TIME PROGRAM

The percentage of trapped gas released from the slurried sludge is 100% (1.00 volume fraction).

The percentage of trapped gas released from the affected settled sludge layer is 50% (0.50 volume fraction).

VARIABLE V_{SOLIDS} CALCULATION – SEISMIC QUIESCENT TIME PROGRAM

All the slurried sludge in the waste tank is considered to release hydrogen during a seismic event.

For waste tanks that contain a saltcake layer of greater than 40 inches overlying settled sludge, the saltcake layer has high enough shear strengths to resist mobilization and gas release from settled sludge during a seismic event. Therefore, the trapped gas release from the settled sludge layer is 0%.

Otherwise, the volume of settled sludge available to liberate hydrogen during a seismic event is proportional to the height of the settled sludge layer and the overlying waste layer above it.

$$\text{Settled sludge volume (gals)}.\frac{\text{Settled sludge layer (inches)}+\text{Total overlying waste layer(inches)}}{\text{400 inches}}$$

Where: Total overlying waste level = Depth of total overlying waste level (including saltcake, slurried sludge, and supernate) above the settled sludge layer

VARIABLE G_S CALCULATION – QUIESCENT TIME PROGRAM

The maximum percentage of trapped bubble gas released from slurried sludge is 20% by volume (0.20 volume fraction) [Ref. 1].

The maximum percentage of trapped bubble gas released from settled sludge is 10% by volume (0.10 volume fraction) [Ref. 1].

4.2.1.2.2 SPONTANEOUS LIBERATION PROTECTION

Waste tanks under Spontaneous Liberation Protection shall maintain the minimum spontaneous time to LFL (CLFL for Tank 50) defined by the waste tank flammability classification. Equations used to calculate the spontaneous time to LFL are provided in Section 4.1.2.2.2. Once the spontaneous time to LFL is calculated, the Spontaneous Quiescent Times for waste tanks under the Spontaneous Liberation Protection Program can be determined using the guidelines below. If a Spontaneous Quiescent Time is required, and thus requires waste tank mixing devices to be run, the quiescent time only considers hydrogen depletion to occur in the slurried sludge layer. If additional solids layers will be impacted by the pump run, the additional trapped hydrogen release must be considered in an associated gas release evaluation.

- If the waste tank is designated as a Very Slow Generation Tank, the waste tank has an infinite Spontaneous Quiescent Time.
- If the spontaneous time to LFL ≥ 28 days and the waste tank is designated as a Slow or Rapid Generation Tank, then waste tank has an infinite Spontaneous Quiescent Time.
- If 7 days ≤ spontaneous time to LFL < 28 days and the waste tank is designated as a Rapid Generation Tank, then waste tank has an infinite Spontaneous Quiescent Time.
- If 7 days ≤ spontaneous time to LFL < 28 days and the waste tank is designated as a Slow Generation Tank, then the waste tank must be reclassified as RAPID or Spontaneous Quiescent Time shall be required. The Spontaneous Quiescent Time will be calculated in the same manner as the Seismic Quiescent Time (see Section 4.2.1.2.1) except only trapped

gas release from slurried sludge is considered and the time it takes for the waste tanks to become flammable is 28 days. Equation 52 in Section 4.2.1.2.1 in which 7-day time to LFL is replaced with 28-day time to LFL (see Equation 62 below) can be used to determine the Spontaneous Quiescent Time. Calculations of those variables in Equation 62 except Q_{H2} can be found in Section 4.2.1.2.1. Variable Q_{H2} calculation is presented in Section 4.1.2.2.1.

Eq. #62
$$t_{spontaneous} = \frac{1}{24} \cdot \frac{V_V^{'}}{\frac{H_R}{100} \cdot Q_{H2} \cdot F_{R,slurried}} \cdot \left(\frac{LFL_{OC} - \frac{Q_{H2}}{Q_{H2} + Q_{ATM}^{'}}}{e^{-(28)(24)\left(\frac{Q_{H2} + Q_{ATM}^{'}}{V_V^{'}}\right)}} - y_0 + \frac{Q_{H2}}{Q_{H2} + Q_{ATM}^{'}} \right)$$

Where:

$t_{spontaneous}$	=	Spontaneous Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Section 4.2.1.2.1 Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft³/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
$Q^{'}_{ATM}$	=	Atmospheric breathing rate, ft^3/hr, (see Section 4.2.1.2.1 Variable $Q^{'}_{ATM}$ Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Section 4.2.1.2.1 Variable H_R Calculation)
y_0	=	Initial hydrogen concentration, vol. frac. y_0 is equal to 3.8% of the LFL_T for Tank 50 and 25% of the LFL_T for other waste tanks (For LFL_T calculation, see Variable LFL_T Calculation in Section 4.2.1.2.1)
$F_{R,slurried}$	=	Fraction of trapped gas released from slurried sludge (see Section 4.2.1.2.1 Variable F_R Calculation)
$V^{'}_v$	=	Vapor space volume using actual or projected waste tank level, ft³, (see Section 4.2.1.2.1 Variable $V^{'}_v$ Calculation)
28	=	Minimum time to LFL, days, required for a Slow tank with spontaneous time to LFL less than 28 days
24	=	Conversion factor from days to hours

- If spontaneous time to LFL < 28 days (excluding immediate spontaneous time to LFL) and the waste tank is designated as a Slow Generation Tank, a Spontaneous Quiescent Time shall be required. Equation 62 above can be used to determine the Spontaneous Quiescent Time for the waste tank.

- If spontaneous time to LFL < 7 days (excluding immediate spontaneous time to LFL) and the waste tank is designated as a Rapid Generation Tank, a Spontaneous Quiescent Time shall be required. Equation 52 in Section 4.2.1.2.1, which is Equation 63 below, can be used to determine the Spontaneous Quiescent Time for the waste tank. Calculation of variable Q_{H2} in Equation 63 is provided in Section 4.1.2.2.1. Other variable calculations are provided in Section 4.2.1.2.1.

Eq. #63 $$t_{spontaneous} = \frac{1}{24} \cdot \frac{V'_V}{\frac{H_R}{100} \cdot Q_{H2} \cdot F_{R,slurried}} \cdot \left(\frac{LFL_{OC} - \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}}{e^{-(7)(24)\left(\frac{Q_{H2}+Q'_{ATM}}{V'_V}\right)}} - y_0 + \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}} \right)$$

Where:

$t_{spontaneous}$	=	Spontaneous Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Section 4.2.1.2.1 Variable LFL_{OC} Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr, (see Section 4.2.1.2.1 Variable Q'_{ATM} Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Section 4.2.1.2.1 Variable H_R Calculation)
y_0	=	Initial hydrogen concentration, vol. frac. y_0 is equal to 3.8% of the LFL_T for Tank 50 and 25% of the LFL_T for other waste tanks (For LFL_T calculation, see Variable LFL_T Calculation in Section 4.2.1.2.1)
$F_{R,slurried}$	=	Fraction of trapped gas released from slurried sludge (see Section 4.2.1.2.1 Variable F_R Calculation)
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3, (see Section 4.2.1.2.1 Variable V'_v Calculation)
7	=	Minimum time to LFL, days
24	=	Conversion factor from days to hours

- If spontaneous time to LFL is immediate and $\mathbf{H'_{eq} \geq LFL_{OC}}$ (H'_{eq}: hydrogen concentration at equilibrium [for calculation, see Section 4.2.1.2.1 Variable H'_{eq} Calculation]; LFL_{OC}: temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. [for calculation, see Section 4.2.1.2.1 Variable LFL_{OC} Calculation]), then
  - If the waste tank is designated as a Slow Generation Tank, the waste tank Spontaneous Quiescent Time can be determined using Equation 62.
  - If the waste tank is designated as a Rapid Generation Tank, the waste tank Spontaneous Quiescent Time can be determined using Equation 63.

- If spontaneous time to LFL is immediate and $\mathbf{H'_{eq} < LFL_{OC}}$ (H'_{eq}: hydrogen concentration at equilibrium [for calculation, see Section 4.2.1.2.1 Variable H'_{eq} Calculation]; LFL_{OC}: temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. [for calculation, see Section 4.2.1.2.1 Variable LFL_{OC} Calculation]), the Spontaneous Quiescent Time can be determined using Equation 54 in Section 4.2.1.2.1, which is Equation 64 below. Calculation of variable Q_{H2} in Equation 64 is provided in Section 4.1.2.2.1. Other variable calculations are provided in Section 4.2.1.2.1.

Eq. #64 $$t_{spontaneous} = \frac{1}{24} \cdot \frac{V'_V}{\left(\frac{H_R}{100}\right) \cdot Q_{H2} \cdot F_{R,slurried}} \cdot (LFL_{OC} - y_0)$$

Where:

$t_{spontaneous}$	=	Spontaneous Quiescent Time, days
LFL_{OC}	=	Temperature and organic corrected hydrogen concentration at 100% LFL, vol. frac. (see Section 4.2.1.2.1 Variable LFL_{OC} Calculation)
y_0	=	Initial hydrogen concentration, 25% of the LFL_T (3.8% of the LFL_T for Tank 50) for Rapid and Slow Generation Tanks, or at the higher of 25% of the LFL_T (3.8% of the LFL_T for Tank 50) or H'_{eq} for Very Slow Generation Tanks), vol. frac. For LFL_T and H'_{eq} calculations, see Section 4.2.1.2.1 Variable LFL_T Calculation and Variable H'_{eq} Calculation, respectively
V'_v	=	Vapor space volume using actual or projected waste tank level, ft^3 (see Section 4.2.1.2.1 Variable V'_V Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (see Section 4.2.1.2.1 Variable H_R Calculation)
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
$F_{R,slurried}$	=	Fraction of trapped gas released from slurried sludge (see Section 4.2.1.2.1 Variable F_R Calculation)
24	=	Conversion factor from hours to days

When the number of waste tank mixing devices available to liberate the retained trapped gas is less than the number of waste tank mixing devices required (e.g., only 3 slurry pumps instead of 4 slurry pumps), the generic methodology defined in Reference 45 can be used to calculate the adjusted Spontaneous Quiescent Time.

4.2.2 NATIONAL FIRE PROTECTION ASSOCIATION SPONTANEOUS QUIESCENT TIME

National Fire Protection Association (NFPA) code (NFPA 69 "Explosion Prevention System") was written to provide guidance in the installation of specific systems for the prevention of explosion. This code is applied to the Tank Farm waste tanks to aid in the control of explosion potential as required per the Standards/Requirements Identification Document (SRID) Section FA-12 "Fire Protection" [Ref. 35].

To quote Reference 35, "The combustible concentration shall be maintained at or below 25 percent of the lower flammability limit unless the following conditions apply: (1) Where automatic instrumentation with safety interlocks is provided, the combustible concentration shall be permitted to be maintained at or below 60% of the lower flammability limit." The flammable limit of 25% of the LFL is established to allow ample time for appropriate actions to take place to prevent the trapped vapors from escalating to a condition where they can become flammable. Purge ventilation systems are installed in the Tank Farm waste tanks to maintain the waste tank vapor space at or below 25% of the LFL. According to Reference 35, given an equivalence of

protection obtained by instituting administrative controls versus installing automatic interlocks for controlling the tanks flammable gas concentration at or below 60% of the LFL, the hydrogen concentration in the waste tank vapor space can be maintained at or below 60% of the LFL_T and therefore meets the requirements defined in NFPA 69. To implement the administrative actions, the configuration of the waste tanks containing slurried sludge should be altered (e.g., reduce the tank level/slurried sludge level) to limit the amount of trapped gas released during a spontaneous liberation event or the waste tank mixing devices should be periodically operated, if required, to release the hydrogen gas trapped in the slurried sludge. The quiescent time requiring the waste tank mixing devices to be operated periodically in the waste tanks containing slurried sludge to limit the trapped gas release from the slurried sludge from causing the waste tank vapor space to exceed 60% of the LFL_T is defined as NFPA Spontaneous Quiescent Time Program. The NFPA Spontaneous Quiescent Time Program is not part of the DSA defined Quiescent Time Program. If an NFPA Spontaneous Quiescent Time is required, and thus requires waste tank mixing devices to be run, the Spontaneous Quiescent Time only considers hydrogen depletion to occur in the slurried sludge layer. If additional solids layers will be impacted by the pump run, the additional trapped hydrogen release must be considered in an associated gas release evaluation.

Upon hydrogen inventory depletion due to waste tank mixing device operation, a portion of hydrogen gas generated from the radiolytic decomposition of water becomes trapped in the slurried sludge. The amount of hydrogen gas retained in the slurried sludge is a function of time until it reaches the maximum inventory (determined based on the maximum trapped bubble gas volume [20% of the affected slurried sludge] and the associated hydrogen percent in trapped gas [determined in Section 4.1.2.2.2 Variable H_{mix} Calculation]). Calculations of variables provided in this section are only applicable to this section unless otherwise noted

The NFPA Spontaneous Quiescent Time will be infinite for a waste tank when the total trapped hydrogen gas ($y_0 + TG_{SS}$) released into the waste tank vapor space is less than or equal to 60% of the LFL_T as expressed below.

Eq. #65 $(y_0 + TG_{SS}) \leq 0.6\ (LFL_T)$

Where:

y_0	=	Initial hydrogen concentration, vol. frac., (see Variable y_0 Calculation)
TG_{SS}	=	Hydrogen concentration due to trapped hydrogen gas release from slurried sludge, vol. frac., (see Variable TG_{SS} Calculation)
LFL_T	=	LFL corrected for temperature (see Variable LFL_T Calculation)

The NFPA Spontaneous Quiescent Time will be infinite for a Very Slow waste tank when the total trapped gas ($y_0 + TG_{SS}$) released into the waste tank vapor space is less than the $LFL_{OC.}$ For LFL_{OC}, see Variable LFL_{OC} Calculation in Section 4.2.1.2.1.

If the total trapped gas release exceeds 60% of the LFL_T, the waste tank configuration must be altered (e.g., reduce waste level, adjust supernate chemistry) or mixing devices must be

periodically operated to limit the volume of trapped gas released from the slurried sludge layer so the resulting hydrogen concentration in the waste tank vapor space is less than or equal to 60% of the LFL_T. The NFPA Spontaneous Quiescent Time and is calculated as follows:

Eq. #66 $$t_{NFPA\ Qtime} = \frac{(y_{60\%} - y_0)\,.\,V'_V}{F_R\,.\,Q_{H_2}\,.\,\frac{H_R}{100}}\,.\,\frac{1}{24}$$

Where:

$t_{NFPA\ Qtime}$	=	NFPA Quiescent Time, days
$y_{60\%}$	=	Hydrogen concentration at 60% of the LFL_T, vol. frac., equal to 0.60 * LFL_T, for LFL_T see Variable LFL_T Calculation
y_0	=	Initial hydrogen concentration, vol. frac. (see Variable y_0 Calculation)
V'_v	=	Vapor space volume based on actual/projected tank level, ft^3 (see Variable V'_v Calculation)
F_R	=	Volume fraction of trapped release (see Variable FR Calculation)
24	=	Conversion factor from hours to days
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge (See Variable H_R Calculation)

When the number of waste tank mixing devices available to liberate the retained trapped gas is less than the number of waste tank mixing devices required (e.g., only 3 slurry pumps instead of 4 slurry pumps), the generic methodology defined in Reference 45 can be used to calculate the adjusted NFPA Spontaneous Quiescent Time.

VARIABLE TG_{SS} CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

The vapor space hydrogen concentration due to trapped gas release from slurried sludge is determined as follows:

Eq. #67 $$TG_{SS} = \frac{V_{SS}\,.\,G_S\,.\,H_{mix}\,.\,C\,.\,F_R}{V'_V}$$

Where:

V_{SS}	=	Volume of slurried sludge, gallons (see Variable V_{ss} Calculation)
G_S	=	Volume fraction of trapped bubble gas, vol. frac. (see Variable G_{Ss} Calculation)
H_{mix}	=	Volume fraction of hydrogen in trapped gas, vol. frac. (see Variable H_{mix} Calculation in Section 4.1.2.2.2)
C	=	Pressure correction factor (see Variable C Calculation)

F_R	=	Volume fraction of trapped gas release (see Variable F_R Calculation)
V'_V	=	Vapor space volume using actual/projected waste tank level, gallons (see Variable V'_v Calculation)
TG_{SS}	=	Volume fraction of hydrogen released from slurried sludge, vol. frac.

VARIABLE V_{SS} CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

All the slurried sludge in the waste tank is considered to release hydrogen during a spontaneous liberation event and is used in determination of TG_{SS} [Ref. 1].

VARIABLE G_S CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

The maximum percentage of trapped bubble gas in slurried sludge is 20% by volume (0.20 volume fraction) [Ref. 1].

VARIABLE F_R CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

The percentage of trapped gas released from the slurried sludge due to spontaneous release is 100% (1.00 volume fraction)

VARIABLE C CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release. The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #68
$$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X} \right) + \frac{1}{2} \frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers above the evaluated slurried sludge layer,
ρ_a	=	Density of layer material above the evaluated slurried sludge layer, kg/m³
ρ_1	=	Density of the evaluated slurried sludge layer material, kg/m³
h_a	=	Height of layer above the evaluated slurried sludge layer, m
h_1	=	Height of the evaluated slurried sludge layer, m
g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325, Pa/atm

VARIABLE H_R CALCULATION – NFPA SPONTANEOUS QUIESCENT TIME

The percentage of hydrogen generated that is retained in the slurried sludge (H_R) is based on the depth of the slurried sludge (until the maximum retained hydrogen value is reached as determined using the maximum trapped bubble gas volume and associated hydrogen percent in trapped gas).

- If the slurried sludge depth is less than 40 inches, 25% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 40 inches and less than 90 inches, 50% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 90 inches and less than 110 inches, 75% of the hydrogen generated is retained.
- If the slurried sludge depth is greater than or equal to 110 inches, 100% of the hydrogen generated is retained.

VARIABLE LFL_T CALCULATION - NFPA SPONTANEOUS QUIESCENT TIME

LFL for hydrogen can be corrected for temperature. Using the Burgess - Wheeler correlation, the temperature corrected LFL for hydrogen, LFL_T, is determined as follows:

Eq. #69 $$LFL_T = LFL_{25C} \cdot [1 - A \cdot (T - 25)]$$

Where:

LFL_T	=	LFL for hydrogen corrected for temperature, vol. frac.
LFL_{25C}	=	LFL for hydrogen at 25°C, (i.e., 0.04-volume fraction), vol. frac.
A	=	Empirical coefficient (Zabetakis attenuation factor), (i.e., 0.0011 per Ref. 1), $^oC^{-1}$
T	=	Temperature at which LFL is to be evaluated in °C [Refs. 1, 24]

VARIABLE y_0 CALCULATION - NFPA SPONTANEOUS QUIESCENT TIME

The initial hydrogen concentration in the vapor space, y_0, for Rapid and Slow Generation Tanks is assumed to be the higher of 2.5% of the LFL_{25C} or a value based on the steady state hydrogen equilibrium concentration accounting for ventilation operation. Use of an initial hydrogen concentration of 2.5% of the LFL_{25C} is considered acceptable due to the fact that the waste tank purge ventilation systems are adequate to maintain the radiolytic hydrogen concentration less than 2.5% of the LFL_{25C} as evidenced by numerous years of waste tank operations and vapor space hydrogen monitoring. For Tank 50, 3.8% of the LFL_T should be used when not classified as Very Slow.

For Very Slow Generation Tanks, the hydrogen concentration at equilibrium (H'_{eq}), accounting for atmospheric breathing only, can be used as the initial hydrogen concentration if the calculated

trapped gas release does not cause the waste tank vapor space to exceed the LFL_{OC}. For H_{eq} calculation, see Variable H_{eq} calculation.

VARIABLE H_{EQ} CALCULATION - NFPA SPONTANEOUS QUIESCENT TIME

For Rapid and Slow Generation Tanks (excluding Tank 50), the initial hydrogen concentration prior to waste tank mixing device operation is assumed to be at steady state hydrogen equilibrium accounting for ventilation (minimum required purge flow for the applicable flammability classification). For Tank 50, the initial hydrogen concentration is 3.8% of the LFL_T. The steady state hydrogen equilibrium ($H_{eq\ (Rapid/Slow)}$) is calculated using the following equation:

Eq. #70 $$H_{eq\ (Rapid/Slow)} = \frac{Q_{H2}}{Q_{H2} + 60.(Q_{purge})}$$

Where:

$H_{eq\ (Rapid/Slow)}$	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} in Section 4.1.2.2.1)
Q_{purge}	=	Purge flow rate, ft^3/min
	=	72 ft^3/min for Rapid tanks; 45 ft^3/min for Slow tanks; 188 ft^3/min for Tanks 40 and 51 when classified as Rapid; In lieu of using the DSA purge flow rates, actual ventilation flow rate may be used
60	=	Conversion factor from mins to hours

The $H_{eq\ (Rapid/Slow)}$ value is compared to 2.5% of the LFL_{25C} (excluding Tank 50) and the greater of the two is used as y_0 in Equation 65 and Equation 66. For Very Slow Generation Tanks, the initial hydrogen concentration is assumed to be at steady state hydrogen equilibrium accounting for atmospheric breathing and is calculated using the expression below:

Eq. #71 $$H'_{eq} = \frac{Q_{H2}}{Q_{H2} + Q'_{ATM}}$$

Where:

H'_{eq}	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total volumetric hydrogen generation rate, ft^3/hr (see Variable Q_{H2} Calculation in Section 4.1.2.2.1)
Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q'_{ATM} Calculation)

VARIABLE Q'_{ATM} CALCULATION - NFPA SPONTANEOUS QUIESCENT TIME

The atmospheric breathing assumptions and methodology are established in Reference 1 Section 3.4.1.5.5. The atmospheric breathing rate is determined as follows:

Eq. #72 $$Q'_{ATM} = \frac{\text{mean atm.fluctuation}}{1013} * \frac{V'_V}{24}$$

Where:

Q'_{ATM}	=	Atmospheric breathing rate, ft^3/hr
mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V'_V	=	Vapor space volume, ft^3, based on actual/projected tank level (see Variable V'_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE V'_v CALCULATION - NFPA SPONTANEOUS QUIESCENT TIME

The vapor space volume is based on the actual or projected waste level. The calculations account for the maximum missing waste volume when considering incoming transfers. The following equation is the vapor space volume calculation, in cubic feet:

Eq. #73 $$V'_V = 0.13368\ [V_T - (L_{tank} \cdot Ff) - MMW]$$

Where:

V'_v	=	Vapor space volume based on actual/projected tank level, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
L_{tank}	=	Actual or projected waste level, inches
0.13368	=	Conversion factor from gallons to ft^3
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Maximum missing waste volume, gallons (to be accounted for in the receipt tank for incoming transfers, see discussion below)

For waste tanks receiving transfers from a sending vessel greater than or equal to 15,000 gallons or has continuous makeup capability, MMW is equal to 15,000 gallons. If the sending vessel is less than 15,000 gallons and does not have continuous makeup capability, MMW is equal to the volume of the vessel. The liquid source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrical or mechanically isolated. In lieu of using the actual/projected waste contents, the evaluation may be based upon the vapor space volume protected by the Tank Fill Limits Program. Liquid additions to the waste tank from DWS do not have continuous makeup capability.

4.2.3 GAS RELEASE MODE QUIESCENT TIME

The Gas Release Mode (GRM) Quiescent Time is defined as the frequency to run the waste tank mixing devices in the waste tanks under Quiescent Time Program to prevent the waste tank vapor space hydrogen concentrations (protected by the HLLCP setpoint) from exceeding the GRM criteria in Section 4.3.2.1. The Gas Release Mode Quiescent Time is not part of the DSA defined

Quiescent Time Program. If a GRM Quiescent Time is required, and thus requires waste tank mixing devices to be run, the GRM Quiescent Time only considers hydrogen depletion to occur in the slurried sludge layer. If additional solids layers will be impacted by the pump run, the additional trapped hydrogen release must be considered in an associated gas release evaluation.

The GRM Quiescent Time may be exceeded; however, the waste tank configuration must be changed (e.g., lower HLLCP, adjust supernate chemistry) or GRM must be entered prior to mixing device operation to control the hydrogen release to less than or equal to the SAV. The methodology to calculate the GRM Quiescent Time for waste tanks in GRM is similar to the methodology used in determining the GRM Quiescent Time (for waste tank not in GRM) except the vapor space for waste tanks in GRM can be calculated using the actual/projected tank levels.

The GRM Quiescent Time will be infinite for a Rapid or Slow Generation Tank if the total trapped hydrogen gas (y_0 + TG) released into the waste tank vapor space is less than or equal to the SAV (not to exceed 60% of the LFL_T), as seen below.

Eq. #74 $(y_0 + TG) \leq SAV$

Where:

y_0	=	Initial hydrogen concentration, vol. frac., (see Variable y_0 Calculation)
TG	=	Hydrogen concentration due to trapped gas release, vol. frac., (see Variable TG Calculation)
SAV	=	Safety Analysis Value used to protect radiolytic time to LFL, nominally equal to 25% LFL_T, but can to go up to 60% LFL_T (see Variable LFL_T Calculation). For Tank 50, it is equal to 3.8% of the LFL_T.

The GRM Quiescent Time will be infinite for a Very Slow Generation Tank if the total trapped hydrogen (y_0 + TG) released into the tank vapor space is less than the LFL_{OC} and the trapped hydrogen gas (TG) is less than or equal to 60% of the LFL_T. For LFL_T and LFL_{OC}, see Variable LFL_T Calculation and Variable LFL_{OC} Calculation, respectively, in Section 4.2.1.2.1.

Eq. #75 $(y_0 + TG) < LFL_{OC}$ AND $TG \leq 60\%\ LFL_T$

The GRM Quiescent Time will be infinite for Tank 50 when classified as a Very Slow Generation Tank if the total trapped hydrogen (y_0 + TG) released into the tank vapor space is less than $LFL_{OC.}$ For LFL_T and LFL_{OC}, see Variable LFL_T Calculation and Variable LFL_{OC} Calculation, respectively, in Section 4.2.1.2.1.

If the total trapped gas release exceeds the SAV or the GRM Quiescent Time is not infinite for a Very Slow Generation Tank, the waste tank configuration must be altered (e.g. reduce HLLCP, adjust chemistry) or mixing devices must be periodically operated to limit the volume of trapped

gas retained in the slurried sludge layer. The frequency to run the waste tank mixing devices to stay out of GRM is calculated as follows:

Eq. #76 $$t_{GRM} = \frac{(y_{SAV} - y_0) \cdot V_V}{F_R \cdot Q_{H_2} \cdot \frac{H_R}{100}} \cdot \frac{1}{24}$$ for Rapid or Slow Generation Tanks

Eq. #77 $$t_{GRM} = \frac{y_{SAV} \cdot V_V}{F_R \cdot Q_{H_2} \cdot \frac{H_R}{100}} \cdot \frac{1}{24}$$ for Very Slow Generation Tanks

Where:

t_{GRM}	=	Frequency to run waste tank mixing devices to stay out of Gas Release Mode, days
y_{SAV}	=	Hydrogen concentration at the SAV, vol. frac., equal to SAV * LFL_T for Rapid and Slow Generation Tanks (excluding Tank 50). For Very Slow Generation Tanks (excluding Tank 50), y_{SAV} is equal to 60% of the LFL_T. For Tank 50, y_{SAV} is equal to 3.8% of the LFL_T when classified as a Rapid or Slow Generation Tank and equal to LFL_{OC} when classified as a Very Slow Generation Tank. For LFL_T, LFL_{OC}, see Variable LFL_T Calculation and Variable LFL_{OC} Calculation, respectively, in Section 4.2.1.2.1
y_0	=	Initial hydrogen concentration, vol. frac. (see Variable y_0 Calculation)
V_v	=	Vapor space volume, ft^3 (see Variable V_v Calculation)
F_R	=	Volume fraction of trapped gas release (see Variable F_R Calculation)
24	=	Conversion factor from hours to days
Q_{H2}	=	Temperature corrected hydrogen generation rate, ft^3/hr (see Section 4.1.2.2.1 Variable Q_{H2} Calculation)
H_R	=	Percentage of hydrogen generation that is retained in slurried sludge, (see Section 4.2.2 Variable H_R Calculation)

When the number of waste tank mixing devices available to liberate the retained trapped gas is less than the number of waste tank mixing devices required (e.g., only 3 slurry pumps instead of 4 slurry pumps), the generic methodology defined in Reference 45 can be used to calculate the adjusted GRM Quiescent Time.

VARIABLE y_0 CALCULATION - GRM QUIESCENT TIME

The initial hydrogen concentration in the vapor space, y_0, of the Rapid and Slow Generation Tanks is assumed to be the higher of 2.5% of the LFL_{25C} or a value based on the steady state hydrogen equilibrium concentration accounting for ventilation operation ($H_{eq(Rapid/Slow)}$). For $H_{eq(Rapid/Slow)}$ calculation, see Variable H_{eq} Calculation below. If $H_{eq(Rapid/Slow)}$ is used as initial hydrogen concentration, it should be increased by an appropriate amount to balance the allowable trapped gas release against the number of vapor space turnovers required, as determined by an engineering evaluation. An adequate number of vapor space turnovers (and/or comparing the tank LFL to a reading obtained using a known LFL concentration) shall be required to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to the assumed initial hydrogen concentration in the hydrogen release evaluation. For Tank 50, vapor space turnovers will be required to reduce the initial hydrogen concentration from 3.8%

of the LFL_T to the higher of 2.5% of the LFL_{25C} or $H_{eq(Rapid/Slow)}$ when not classified as a Very Slow Generation Tank.

For Very Slow Generation Tanks, the greater of 2.5% of the LFL_{25C} or H_{eq}, accounting for atmospheric breathing only (see Equation 82), can be used as the initial hydrogen concentration if the calculated trapped gas release does not cause the tank vapor space to exceed the LFL_{OC}. If using H_{eq} as the initial hydrogen concentration causes the waste tank vapor space to exceed the LFL_{OC} upon releasing the trapped hydrogen, 2.5% of the LFL_{25C} may be used as the initial hydrogen concentration; however, vapor space turnovers or hydrogen monitoring shall be required prior to each trapped gas release activity to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to 2.5% of the LFL_{25C}. For H_{eq} calculation, see Variable H_{eq} calculation.

The required number of vapor space turnovers for each tank will be documented in the ERD [Ref. 2]. The methodology specified in Reference 15 with a mixing efficiency of 0.2 shall be employed to determine the adequate number of vapor space turnovers. The mixing efficiency of 0.2 is based on the recommended value from NFPA 69 Annex D for the ventilation system arrangement (single exhaust opening, non-positive supply ventilation system) [Ref. 13]. However, vapor space turnovers and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration can be employed to ensure that the waste tank bulk vapor space hydrogen concentration is less than or equal to the initial value assumed in the hydrogen release engineering evaluation. If the latter option is used (not applicable to Tank 50), the methodology to determine the flammable vapor concentration shall be consistent with the requirements of Reference 7. Because the initial hydrogen concentration for Tank 50 cannot be measured, and hydrogen monitoring is not required for Tank 50, vapor space turnovers will be performed in Tank 50, when classified as a Rapid or Slow tank, to reduce the initial hydrogen concentration from 3.8% of the LFL_T to the higher of 2.5% of the LFL_{25C} or $H_{eq(Rapid/Slow)}$. As a Very Slow waste tank, vapor space turnovers can be used in Tank 50 to reduce the equilibrium concentration to 2.5% of the LFL_{25C} if necessary. Vapor space turnover requirements for Tank 50, when necessary, will have to be met by ACTUAL vapor space turnovers, using the calculation in the ERD [Ref. 2] to determine the "Ventilation Time (hr)" to achieve this.

VARIABLE TG CALCULATION – GRM QUIESCENT TIME

The vapor space hydrogen concentration due to trapped gas release from slurried sludge is determined as follows:

Eq. #78 $$TG = \frac{V_{solids} \cdot G_S \cdot H_{mix} \cdot C \cdot F_R}{V_V}$$

Where:

V_{solids}	=	Volume of slurried sludge, gallons (see Variable V_{solids} Calculation)
G_S	=	Volume fraction of trapped bubble gas, vol. frac. (see Variable G_S Calculation)
H_{mix}	=	Volume fraction of hydrogen in trapped gas, vol. frac. (see Variable H_{mix} Calculation in Section 4.1.2.2.2)

C	=	Pressure correction factor (see Variable C Calculation)
F_R	=	Volume fraction of trapped gas release (see Variable F_R Calculation)
V_V	=	Vapor space volume protected by HLLCP setpoint, gallons (see Variable V_v Calculation below for waste tanks not entering GRM)
TG	=	Volume fraction of hydrogen released from slurried sludge, vol. frac.

VARIABLE V_{SOLIDS} CALCULATION – GRM QUIESCENT TIME

All the slurried sludge in the waste tank is considered to release hydrogen [Ref. 1].

VARIABLE G_S CALCULATION – GRM QUIESCENT TIME

The maximum percentage of trapped bubble gas released from slurried sludge is 20% by volume (0.20 volume fraction) [Ref. 1].

VARIABLE F_R CALCULATION – GRM QUIESCENT TIME

The percentage of trapped gas released from the slurried sludge is 100% (1.00 volume fraction)

VARIABLE C CALCULATION – GRM QUIESCENT TIME

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release due to agitation. The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #79
$$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X}\right) + \frac{1}{2}\frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers above the evaluated slurried sludge layer,
ρ_a	=	Density of layer material above the evaluated slurried sludge layer, kg/m³
ρ_1	=	Density of the evaluated slurried sludge layer material, kg/m³
h_a	=	Height of layer above the evaluated slurried sludge layer, m
h_1	=	Height of the evaluated slurried sludge layer, m
g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325, Pa/atm

VARIABLE V_V CALCULATION – GRM QUIESCENT TIME

The HLLCP is credited in the evaluation to determine whether entry into GRM will be required prior to sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities in a waste tank. The GRM Quiescent Time is to protect the vapor space hydrogen concentration for the waste tank from exceeding the Gas Release Criteria. Therefore, the GRM Quiescent Time shall be calculated based on the waste tank vapor space protected by the HLLCP setpoint. The following equation is the vapor space volume calculation in units of ft^3.

Eq. #80 $$V_V = 0.13368\,[V_T - (L_{HLLCP} + IU) * Ff - MMW]$$

Where:

V_v	=	Vapor space volume based on HLLCP setpoint, ft^3
V_T	=	Total tank vapor space volume (empty tank), gallons
L_{HLLCP}	=	Level of HLLCP setpoint, inches
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Maximum volume associated with a Transfer Error event, equal to 15,000 gallons
IU	=	Uncertainty attributed to HLLCP, inches [see Ref. 12]
0.13368	=	Conversion factor from gallons to ft^3

VARIABLE H_{EQ} CALCULATION - GRM QUIESCENT TIME

For Rapid and Slow Generation Tanks, steady state hydrogen equilibrium accounting for ventilation (minimum required purge flow for the applicable flammability classification) may be used as the assumed initial hydrogen concentration prior to waste tank mixing device operation. The steady state hydrogen equilibrium ($H_{eq\ (Rapid/Slow)}$) is calculated using the following equation:

Eq. #81 $$H_{eq\ (Rapid/Slow)} = \frac{Q_{H2}}{Q_{H2} + 60.(Q_{purge})}$$

Where:

$H_{eq\ (Rapid/Slow)}$	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} in Section 4.1.2.2.1)
Q_{purge}	=	Minimum purge flow rate, ft^3/min
	=	72 ft^3/min for Rapid tanks 45 ft^3/min for Slow tanks
60	=	Conversion factor from mins to hours

The $H_{eq\ (Rapid/Slow)}$ value is compared to 2.5% of the LFL_{25C} and the greater of the two is used as y_0 in Equations 74 and 76.

For Very Slow Generation Tanks, steady state hydrogen equilibrium accounting for atmospheric breathing may be used as the assumed initial hydrogen concentration and is calculated using the expression below:

Eq. #82 $$H_{eq} = \frac{Q_{H2}}{Q_{H2} + Q_{ATM}}$$

Where:

H_{eq}	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total volumetric hydrogen generation rate, ft^3/hr (see Variable Q_{H2} Calculation in Section 4.1.2.2.1)
Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr (see Variable Q_{ATM} Calculation)

The H_{eq} value is compared to 2.5% of the LFL_{25C} and the greater of the two is used as y_0 in Equation 75.

VARIABLE Q_{ATM} CALCULATION - GRM QUIESCENT TIME

The atmospheric breathing assumptions and methodology are established in Reference 1 Section 3.4.1.5.5. The atmospheric breathing rate is determined as follows:

Eq. #83 $$Q_{ATM} = \frac{\text{mean atm.fluctuation}}{1013} * \frac{V_V}{24}$$

Where:

Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr
mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V_V	=	Vapor space volume, ft^3, based on HLLCP level (see Variable V_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

4.2.4 IMPLEMENTATION ACTIONS

1. The Seismic Release Protection Quiescent Time and Spontaneous Liberation Protection Quiescent Time shall be determined using WCS [Ref. 11] or an engineering evaluation and documented in the ERD. [TSR SAC 5.8.2.28.a]

2. The NFPA 69 Quiescent Time and GRM Quiescent Time shall be determined using WCS [Ref. 11] or an engineering evaluation and documented in the ERD.

3. The Quiescent Time Program (Seismic Release Protection) shall be tracked by CST Operations to ensure that waste tanks will not reach LFL_{OC} in less than 7 days following a

seismic event. [TSR SAC 5.8.2.28.b]

4. The Quiescent Time Program (Spontaneous Liberation Protection) shall be tracked by CST Operations to ensure that the minimum time to LFL (CLFL for Tank 50) defined by the waste tank flammability classification is maintained. [TSR SAC 5.8.2.28.c]

5. Operating procedures shall address the requirement to perform an adequate number of vapor space turnovers and/or compare the tank LFL reading to a reading obtained using a known LFL concentration to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to the value assumed in WCS [Ref. 11] or in an engineering evaluation prior to initiating waste tank mixing devices operation. If the flammable vapor concentration method (i.e., comparing the tank LFL reading) is implemented, the methodology used to determine the flammable vapor concentration shall be consistent with the requirements of Ref. 7.

6. Transferring slurried sludge into a non-quiescent time waste tank will require the receipt tank to be placed into the quiescent time. [TSR SAC 5.8.2.28.a]

7. When transferring settled/slurried sludge between quiescent time waste tanks, a pre-evaluation shall be performed to determine quiescent time impacts for the waste tanks. [TSR SAC 5.8.2.28.a]

8. If the evaluated activity results in a non-conservative change in the quiescent time (e.g., a reduction of allowable time between tank agitation) or tank flammability classification (e.g., SLOW to RAPID, VERY SLOW to RAPID), the projected changes will be updated in the ERD and implemented in the facility via the ERD linking procedure [Ref. 55] prior to initiation of the planned activity. The quiescent time will be re-evaluated and re-updated in the ERD once the activity is complete.

9. The ERD shall track the GRM Quiescent Time for waste tanks under Quiescent Time Program to protect the waste tanks from exceeding the Gas Release Criteria stated in Section 4.3.2.1.

10. Trapped gas release activities in Tank 50 that could exceed the Tank 50 Gas Release Criteria (see Section 4.3.2.1) are prohibited. Therefore, Tank 50 is prohibited from entering GRM. The GRM Quiescent Time for Tank 50 must be infinite. If not infinite, the tank GRM Quiescent Time must not be exceeded.

11. Prior to initiation of operation of mixing devices in a settled sludge layer at each waste tank mixing device height, an evaluation shall be performed to determine the waste tank's Quiescent Time (assuming completion of 10 days of mixing). The results of this evaluation will be documented in the ERD prior to starting the mixing devices. In the event the 10 day mixing time is not completed, the waste tank's Quiescent Time will be reverted back to prior condition and a new ERD will be issued. [TSR SAC 5.8.2.28.a]

12. If a waste tank mixing device is lowered prior to completion of successful sludge agitation, the affected sludge layer within the zone of influence of the waste tank mixing devices (based on the mixing device location prior to lowering) shall be considered slurried sludge [Ref. 1].

13. There have been no operational experiences or studies to determine when adequate mixing occurs after completion of an SBP run. Therefore, operation of the SBPs cannot be used to credit any DSA or non-DSA defined Quiescent Times.

4.3 GAS RELEASE PROGRAM

The Gas Release Program does not apply to Type I/II Acidic Chemical Cleaning Waste Tanks or waste tanks in Closure Mode. Information in this section pertaining to bulk saltcake dissolution and saltcake interstitial liquid removal activities does not apply to Type I/II Non-Acidic Chemical Cleaning Waste Tanks. Bulk saltcake dissolution and saltcake interstitial liquid removal activities in Type I/II Non-Acidic Chemical Cleaning Waste Tanks are prohibited.

The Gas Release Program is not applicable to **operational** activities in waste tanks that have the potential to release insignificant amount**s** of hydrogen and do not require an engineering evaluation**. The Gas Release Program has the following applicability related to those unintended transitions that may occur between certain activities:**

- **Unintended transition between free supernate removal and saltcake interstitial liquid removal. The controls associated with free supernate removal provide adequate protection for a trapped gas release, and the controls associated with saltcake interstitial liquid removal in Gas Release Program are not required for this unintended transition.**

- **Water or dilute supernate addition onto exposed saltcake after unintended transition between free supernate removal and saltcake interstitial liquid removal. The controls associated with bulk saltcake dissolution in the Gas Release Program are not required for this activity following the unintended transition.**

  Although certain controls in the Gas Release Program are not required for these activities if associated with unintended transition, once the facility becomes cognizant of the actual condition the facility shall follow the appropriate controls for subsequent activities. For example, if the facility recognizes that actual saltcake level would indicate that saltcake interstitial liquid removal activity is occurring versus free supernate removal activity, then subsequent activities related to this process shall follow controls associated with saltcake interstitial liquid removal.

The Gas Release Program provides safety functions to protect hydrogen concentrations assumed for the waste tank bulk vapor space during the following planned operational activities:

- Free Supernate Removal

- Sludge Agitation

- Bulk saltcake dissolution

- Saltcake Interstitial Liquid Removal

The Gas Release Program shall utilize the following requirements to protect hydrogen concentrations assumptions in the waste tank bulk vapor space during waste tank mixing device operation, bulk saltcake dissolution, saltcake interstitial liquid removal or free supernate removal.

- Prior to initiating sludge agitation (using waste tank mixing devices), bulk saltcake dissolution, or saltcake interstitial liquid removal activities, determine if the activity will cause the waste tank to enter Gas Release Mode [TSR SAC 5.8.2.29.a]

- Prior to initiating sludge agitation (using waste tank mixing devices), bulk saltcake dissolution, or saltcake interstitial liquid removal activities, ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to the initial value assumed in the hydrogen release engineering evaluation (by verifying adequate number of tank vapor space turnovers, verifying vapor space hydrogen concentration, or combination of the preceding two methodologies). [TSR SAC 5.8.2.29.b]

- For waste tanks in Gas Release Mode undergoing sludge agitation (using waste tank mixing devices), bulk saltcake dissolution, or saltcake interstitial liquid removal activities, the activity shall be controlled to maintain the waste tank bulk vapor space hydrogen concentration less than or equal to the safety analysis value and maintain the minimum time to LFL defined by the waste tank flammability classification. [TSR SAC 5.8.2.29.c]

- Prior to initiating free supernate removal activities (excluding Very Slow Generation Tanks), ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to 2.5% of the LFL (by verifying adequate number of tank vapor space turnovers, verifying vapor space hydrogen concentration, or combination of the preceding two methodologies). [TSR SAC 5.8.2.29.d]

- Prior to initiating free supernate removal activities, ensure that the resultant free supernate hydrogen release rate is less than or equal to the limits of Table 1 for the associated waste tank type and flammability classification. [TSR SAC 5.8.2.29.e]

Table 1: Free Supernate Removal Hydrogen Release Rate Limits by Waste Tank Flammability Classification

Tank Type	Waste Tank Flammability Classification		
	Rapid Generation Tank	Slow Generation Tank	Very Slow Generation Tank
Type I	$HR_{FSR} \leq 187$	$HR_{FSR} \leq 163$	$HR_{FSR} \leq 89$
Type II	$HR_{FSR} \leq 226$	$HR_{FSR} \leq 207$	$HR_{FSR} \leq 111$
Type III/IIIA	$HR_{FSR} \leq 223$	$HR_{FSR} \leq 212$	$HR_{FSR} \leq 113$
Type IV	$HR_{FSR} \leq 233$	$HR_{FSR} \leq 232$	$HR_{FSR} \leq 122$

(HR_{FSR} is total gallons of hydrogen released per inch of liquid removed during free supernate removal)

The Free Supernate Removal Hydrogen Release Rate Limits stated above were derived in Reference 53 to ensure that free supernate removal activities will maintain the minimum time to LFL (CLFL for Tank 50) defined by the waste tank flammability classification (and associated minimum ventilation flow rate requirements) [Ref. 1].

- Prior to operation of a waste tank mixing device in a waste tank containing only slurried sludge (for a mixing device that has not been operated within 180 days), ensure the waste tank level is within the limits of Table 2 to ensure adequate vapor space volume for flammable transients. [TSR SAC 5.8.2.29.f]

Table 2: Waste Tank Level Limitations for Flammable Transients – Slurried Sludge

Waste Tank Conditions (for H_{mix} determination, see Section 4.1.2.2.2 Variable H_{mix} Calculation)	Waste Tank Type and Maximum Level (in inches from the bottom of the tank)			
	I	II	III/IIIA	IV
$H_{mix} \leq 37.5\%$ and waste tank mixing device discharge totally clear of sludge	274	304	376	411
$H_{mix} \leq 37.5\%$ and waste tank mixing device discharge partially or fully submerged in sludge	215	245	317	397
$H_{mix} > 37.5\%$ and waste tank mixing device discharge totally clear of sludge	254	284	356	411
$H_{mix} > 37.5\%$ and waste tank mixing device discharge partially or fully submerged in sludge	136	166	238	318

For trapped gas releases associated with mechanically disturbing waste, the potential flammable transients in the tank vapor space are short-lived (less than 3 minutes) [Ref. 18]. Transfers into waste tanks are not normally occurring during waste tank mixing device operation. Additionally, it would take at least 60 minutes to transfer the entire assumed maximum missing waste volume (assuming transfer flow rate of 250 gpm); therefore, the waste tank level limitations for flammable transient given in Table 2 do not need to be adjusted for the maximum volume associated with a Transfer Error event (i.e., 15,000 gallons) or instrument uncertainties.

- Prior to operation of a waste tank mixing device in a waste tank containing saltcake, settled sludge, or any combination of saltcake, settled sludge, or slurried sludge, ensure the waste tank level is within the limits of Table 3 to ensure adequate vapor space volume for flammable transients. [TSR SAC 5.8.2.29.g]

Table 3: Waste Tank Level Limitations for Flammable Transients – Saltcake, Settled Sludge or Any Combination of Saltcake, Settled Sludge, or Slurried Sludge

Waste Tank Conditions (for H_{mix} determination, see Section 4.1.2.2.2 Variable H_{mix} Calculation)	Waste Tank Type and Maximum Level (in inches from the bottom of the tank)			
	I	II	III/IIIA	IV
$H_{mix} \leq 37.5\%$ and waste tank mixing device discharge totally clear of saltcake <u>and</u> sludge	274	304	376	411
$H_{mix} \leq 37.5\%$ and waste tank mixing device discharge partially or fully submerged in saltcake <u>or</u> sludge	215	245	317	397
$H_{mix} > 37.5\%$ and waste tank mixing device discharge totally clear of saltcake <u>and</u> sludge	254	284	356	411
$H_{mix} > 37.5\%$ and waste tank mixing device discharge partially or fully submerged in saltcake <u>or</u> sludge	136	166	238	318

For trapped gas releases associated with mechanically disturbing waste, the potential flammable transients in the tank vapor space are short-lived (less than 3 minutes) [Ref. 18]. Transfers into waste tanks are not normally occurring during waste tank mixing device operation. Additionally, it would take at least 60 minutes to transfer the entire assumed maximum missing waste volume (assuming transfer flow rate of 250 gpm); therefore, the waste tank level limitations for flammable transient given in Table 3 do not need to be adjusted for the maximum volume associated with a Transfer Error event (i.e., 15,000 gallons) or instrument uncertainties.

As stated in Section 3.0, waste tank mixing devices refers to any of the following: slurry pumps (any type), SMPs, SBPs, or CSMPs.

The SBP Operation Program shall ensure the entrained waste has less than or equal to 1 wt% sludge solids. The program shall at a minimum include the following attributes during SBP operation [TSR SAC 5.8.2.58]:

- The suction of the SBP shall be a minimum of 152 inches from the sludge layer.
- The speed of the SBP shall be less than or equal to 860 rpm.

Additional controls shall be implemented as necessary to minimize the amount of sludge solids in suspension during SBP operations based on evaluation of the following phenomena:

- Tank agitation
- Effects of receiving waste transfers

4.3.1 FREE SUPERNATE REMOVAL ACTIVITIES

Prior to a planned free supernate removal activity, an engineering evaluation shall be performed to verify that the resultant release of hydrogen due to the activity is less than or equal to the hydrogen release rate limits provided in Table 1 for the associated waste tank type and waste tank flammability classification.

The initial hydrogen concentration used for the derivation of the free supernate removal hydrogen release rate limits is assumed to be 2.5% of the LFL_{25C}, excluding Very Slow Generation Tanks. Therefore, prior to initiating free supernate removal activities, the waste tank bulk vapor space shall be ventilated for an adequate number of vapor space turnovers to reduce the hydrogen concentration from the SAV to less than or equal to 2.5% of the LFL_{25C} or shall be verified by hydrogen monitoring to be less than or equal to 2.5% of the LFL_{25C} or combining the two preceding methodologies. Free supernate removal cannot be performed in Tank 50 when classified as a Rapid or Slow Generation Tank. Transfers from Tank 50 when classified as a Rapid or Slow Generation Tank should occur within 48 hours of successful trapped hydrogen depletion by sludge agitation.

The bulk vapor space hydrogen concentration shall be verified to be less than or equal to 2.5% of the LFL_{25C} within 4 days prior to initiating of free supernate removal activities [Ref. 43]. Due to the conservative inputs and assumptions (e.g., bounding sludge slurry radiolytic hydrogen generation rate, minimum purge ventilation flow rate) used in establishing the Free Supernate Removal Hydrogen Release Rate Limits and the requirements of continuous operation of purge ventilation system for Slow and Rapid Generation Tanks, verification within 4 days is considered acceptable. The data sheets in Reference 56 provide the portable LFL monitor sampling results for Tanks 30, 32, 35, 36, 37, 39, 40, 41, 42, 43, and 51 when classified as Rapid Generation Tanks from 5/26/15 thru 8/3/15. As can be seen from the data sheets, at no time was a value above 0% of the LFL recorded for Tanks 30, 32, 35, 36, 37, 41, 43, and 51. Tanks 39 and 42 LFL monitor sampling results were recorded at 1% and 2% one time, respectively. Tank 40 LFL monitor sampling results only went up to 5% of the LFL during and after completion of slurry pump operations. The data sets indicated that when no trapped gas release activities performed in the waste tanks the bulk vapor space hydrogen concentration in the waste tanks remained well below 2.5% of the LFL_{25C}.

For Very Slow Generation Tanks, the methodology to establish the hydrogen release rate limits is conservatively based on no ventilation flow during free supernate removal. The vapor space is segregated into two parts corresponding to the initial vapor space volume and the additional vapor space volume created from the removal of free supernate out of the tank. Given this

approach, the hydrogen concentration in the waste tank bulk vapor space generated by radiolysis or liberated during free supernate removal is maintained to be less than LFL.

The limits derived for free supernate removal activities maintain the waste tank flammability classification for time to LFL (CLFL for Tank 50), but do not necessarily protect the hydrogen concentration SAV established by the Flammability Control Program. However, excluding Very Slow Generation Tanks, the hydrogen concentration does not exceed 60% of the LFL during the free supernate removal activity.

Waste tank flammability classification may be reclassified, based on the engineering evaluation, to meet the above criteria. For example, an evaluation determines that, for a Type I and Slow Generation Tank, the assumed hydrogen release due to the free supernate removal activity exceeds the hydrogen release rate limit of 163 gallons per inch of liquid removed, but is less than the limit for a Type I Rapid Generation Tank. In this case, the tank is at risk for becoming flammable in less than 28 days during the free supernate removal activity and should be reclassified as a Rapid Generation Tank.

For waste tanks undergoing sludge agitation using waste tank mixing devices concurrent with the outgoing transfer (or had undergone sludge agitation within 48 hours prior to completion of the transfer), trapped gas release from the slurried sludge layer may be discounted from the evaluation if hydrogen depletion success has been accomplished by the criteria/methodology in Section 4.2.1.1.

4.3.1.1 FREE SUPERNATE REMOVAL METHODOLOGY

A transfer of free supernate out of the tank lowers the hydrostatic pressure on the saltcake and/or sludge layers. The term “sludge” refers to both settled sludge and slurried sludge. A reduction in hydrostatic pressure, ΔP, on the saltcake and/or sludge layers is accompanied by a reduction in the moles of gas, Δn, trapped in the saltcake and/or sludge layers at constant volume and temperature according to the Ideal Gas Law.

$$\Delta n = \frac{\Delta P \,.\, V}{R \,.\, T}$$

Where:

Δn	=	Moles of trapped gas, moles
R	=	Gas constant, $\frac{gal.atm}{mol.K}$
V	=	Volume of trapped gas, gallons
T	=	Temperature of trapped gas, Kelvin

The moles of hydrogen in the trapped gas, Δn_{H_2}, released due to head reduction in the waste tank during free supernate removal can be expressed as:

$$\Delta n_{H_2} = \frac{\Delta P \,.\, V_{H_2}}{R \,.\, T_{solids}}$$

Where:

Δn_{H_2}	=	Moles of hydrogen in the trapped gas, moles
ΔP	=	Hydrostatic pressure reduction, atm
V_{H2}	=	Volume of hydrogen in trapped gas, gallons
T_{solids}	=	Temperature of salt and/or sludge layers, Kelvin
R	=	Gas constant, $\frac{gal.atm}{mol.K}$

The volume of hydrogen, V_{H_2} , in the trapped gas in the saltcake and/or sludge layers is calculated in the equation below.

$$V_{H_2} = V_{solids} \,.\, G_s \,.\, H_{mix}$$

Where:

V_{H_2}	=	Volume of hydrogen in trapped gas, gallons
V_{solids}	=	Volume of saltcake and/or sludge layer, gallons
G_s	=	Fraction of trapped bubble gas, vol. frac.
H_{mix}	=	Fraction of hydrogen in trapped gas, vol. frac.

Substituting V_{H_2} into Δn_{H_2} yields

$$\Delta n_{H_2} = \frac{\Delta P \,.\, V_{solids} \,.\, G_s \,.\, H_{mix}}{R \,.\, T_{solids}}$$

Releasing the moles of hydrogen (i.e, Δn_{H_2}) results in a hydrogen release volume, ΔV_{H_2}, of:

$$\Delta V_{H_2} = \frac{R \,.\, T_{H_2} \,.\, \Delta n_{H_2}}{P_{atm}}$$

Where:

ΔV_{H_2}	=	Volume of hydrogen released, gallons
P_{atm}	=	Ambient pressure, atm
R	=	Gas constant, $\frac{gal.atm}{mol.K}$
T_{H_2}	=	Temperature of trapped hydrogen gas, Kelvin

Substituting Δn_{H_2} into ΔV_{H_2} yields the following expression for ΔV_{H_2}.

$$\Delta V_{H_2} = \frac{T_{H_2} \cdot \Delta P \cdot V_{solids} \cdot G_s \cdot H_{mix}}{T_{solids} \cdot P_{atm}}$$

Where:

ΔV_{H_2}	=	Volume of hydrogen released, gallons
T_{H_2}	=	Temperature of trapped hydrogen gas, Kelvin
ΔP	=	Hydrostatic pressure reduction, atm
V_{solids}	=	Volume of saltcake and/or sludge layer, atm
G_s	=	Fraction of trapped bubble gas, vol. frac.
H_{mix}	=	Fraction of hydrogen in trapped gas, vol. frac.
T_{solids}	=	Temperature of saltcake and/or sludge layer, Kelvin
P_{atm}	=	Ambient pressure, atm

Hydrostatic pressure reduction, ΔP, per inch of liquid removed is expressed in the following equation:

$$\Delta P = \frac{0.0254\ (\rho \cdot g)}{1.01325E + 05}$$

Where:

ΔP	=	Hydrostatic pressure reduction, atm
ρ	=	Density of liquid removed, kg/m^3
g	=	Standard acceleration of gravity (9.81 m/s^2)
0.0254	=	Conversion factor from inches to meters
1.01325E+05	=	Conversion factor from atms to Pas (N/m^2)

Due to heat generated from the radionuclides present in the salt and sludge layers, the salt and sludge temperature (T_{solids}) is higher than the ambient temperature (T_{H2}). Increasing the T_{solids} value in the ΔV_{H_2} equation above reduces the volume of hydrogen released due to free supernate removal. For conservatism, it is assumed that T_{solids} is equal to T_{H2}. The volume of trapped hydrogen gas released per inch of free supernate removal for each applicable solids layer is given by the following expression after combining the ΔV_{H_2} and ΔP equations and simplifying the resultant equation.

Eq. #84 $$\Delta V_{H_2} = \frac{0.0254}{1.01325E{+}05} \cdot \frac{\rho \cdot g \cdot V_{solids} \cdot G_s \cdot H_{mix}}{P_{atm}}$$

Where:

ΔV_{H_2}	=	Volume of trapped hydrogen gas released per inch of free liquid removed, gallons
ρ	=	Density of liquid removed, kg/m^3
g	=	Standard acceleration of gravity (9.81 m/s^2)

0.0254	=	Conversion factor from inches to meters
1.01325E+05	=	Conversion factor from atms to Pas (N/m^2)
V_{solids}	=	Volume of saltcake, settled sludge or slurried sludge layer below the affected waste removed, gallons (see discussion below)
G_s	=	Fraction of trapped bubble gas in solids layers, vol. frac., equal to 0.11 if in saltcake; 0.10 if in sludge; 0.20 if in slurried sludge
H_{mix}	=	Fraction of hydrogen in trapped gas, vol. frac. For H_{mix} calculation see Section 4.1.2.2.2 Variable H_{mix} Calculation
P_{atm}	=	Ambient pressure, atm

The total volume of hydrogen released per inch of free supernate removal is a summation of the volumes of hydrogen released per inch of free supernate removal from each applicable solids layer. The total volume is then compared against Table 1 for the applicable waste tank type and flammability classification.

Reference 17 calculates the volume of dissolved hydrogen release per inch of free supernate removal during a steam jetted transfer. For waste tanks undergoing free supernate removal activity concurrent with receiving a steam jetted transfer, the total volume of hydrogen gas released per inch of free liquid removed is the volume of dissolved hydrogen released due to steam jetted transfers (obtained from Ref. 17) in addition to the volume of hydrogen released due to free supernate removal (calculated from Equation 84) [Ref. 43].

Eq. #85 $$\Delta V_{total\ H_2} = \frac{0.0254}{1.01325E+05} \cdot \frac{\rho . g . H_{mix}}{P_{atm}} \cdot \sum_1^n (V_{solids} \cdot G_S) + \Delta V_{dissolved\ H_2}$$

Where:

$\Delta V_{total\ H_2}$	=	Total volume of hydrogen gas released per inch of liquid removed due to free supernate removal and steam jetted transfers, gallons
ρ	=	Density of liquid removed, kg/m^3
g	=	Standard acceleration of gravity (9.81 m/s^2)
0.0254	=	Conversion factor from inches to meters
1.01325E+05	=	Conversion factor from atms to Pas (N/m^2)
n	=	Number of solids layers
V_{solids}	=	Volume of saltcake, settled sludge or slurried sludge layer below the affected waste removed, gallons (see discussion below)
G_s	=	Fraction of trapped bubble gas in solids layers, vol. frac., equal to 0.11 if in saltcake; 0.10 if in sludge; 0.20 if in slurried sludge

H_{mix}	=	Fraction of hydrogen in trapped gas, vol. frac. For H_{mix} calculation see Section 4.1.2.2.2 Variable H_{mix} Calculation
P_{atm}	=	Ambient pressure, atm
$\Delta V_{dissolved\ H_2}$	=	Volume of dissolved hydrogen released on inch of free liquid removed basis, gallons

The total hydrogen volume, $\Delta V_{total\ H_2}$, is then compared against Table 1 for the applicable waste tank type and flammability classification.

For waste tanks undergoing sludge agitation using waste tank mixing devices concurrent with the outgoing transfer (or had undergone sludge agitation within 48 hours of completion of the transfer), trapped gas release from the slurried sludge layer may be discounted from the evaluation if hydrogen depletion success had been accomplished by the criteria/methodology in Section 4.2.1.1 (e.g., completion of 8-hour slurry pump/CSMP operation at maximum allowable speed with evidence of adequate sludge mixing). The 48-hour period (for a waste tank that had previously undergone sludge agitation) is based on engineering judgement. This time period is considered reasonably conservative since sludge slurry would need sufficient time for the sludge solids to settled (via the free settling phase) and generate/retain any appreciable radiolytic hydrogen [Ref. 1].

4.3.1.2 IMPLEMENTATION ACTIONS

1. Operating procedures shall address the requirement to perform an adequate number of vapor space turnovers and/or compare the tank LFL reading to a reading obtained using a known LFL concentration to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to 2.5% of the LFL_{25C} prior to initiating free supernate removal activities excluding Very Slow Generation Tanks. Operating procedures shall address the requirement to have second person verification of vapor space turnovers time and/or comparison of the hydrogen concentration reading to the hydrogen concentration acceptance value. If the flammable vapor concentration method (i.e., comparing the tank LFL reading) is implemented, the methodology used to determine the flammable vapor concentration shall be consistent with the requirements of Reference 7. [TSR SAC 5.8.2.29.d]

2. Prior to initiating free supernate removal activities, the bulk vapor space hydrogen concentration for the waste tanks shall be verified to be less than or equal to 2.5% of the LFL_{25C} per one of the following methods:
   a) By performing the verification in the respective transfer procedure prior to, but as close as practicable, to starting the prime mover
   OR

   b) By performing the verification via procedure (e.g., roundsheets) and subsequently confirming in the respective transfer procedure, as close as practicable to starting the prime mover, that the verification was performed within 4 days of the same shift (e.g., day 1 day shift to day 5 day shift) provided the following requirements are met [Ref. 43]:

   - No additional trapped gas release activities (e.g., waste tank mixing device operation, bulk saltcake dissolution) have occurred in the tank since the bulk vapor space hydrogen

concentration was verified to be less than or equal to 2.5% of the LFL_{25C}.

- No hydrogen releasing activities have been performed in the waste tank since the bulk vapor space hydrogen concentration was verified to be less than or equal to 2.5% of the LFL_{25C}, except the following activities [Ref. 43]:
  - Flushing of transfer pumps or jets. In tanks where the highest solids layer is slurried sludge, the separation distance between the transfer pump/jet suction and the slurried sludge layer must meet the requirements of the SCOM Program PDD [Ref. 9] to be considered an insignificant hydrogen releasing activity. In tanks where the highest solids layer is settled sludge or saltcake, there is no minimum separation criteria required to perform flushing.
  - Flushing of ventilation system components
  - Sample rinsing
  - Flushing of waste level measurement devices (e.g., reel tape, radar, steel tape, turbidity meter, salt spike, wafer)
  - Filling the purge condenser seal leg
  - Lifting the evaporator pot to the associated drop tank
  - Limited duration (5 minutes or less) operation of transfer pump in recirculation in a waste tank containing saltcake

  For those activities involving a very small quantity of water (e.g., several gallons per activity), the performance of the activities is not limited, individually or in combination with other activities, between the initial hydrogen verification check and the start of the free supernate removal activity. These activities are sample rinsing, flushing of waste level measurement devices (e.g., reel tape, radar, steel tape, turbidity meter, salt spike, wafer).

  The following activities are considered to individually result in insignificant hydrogen release. These allowed activities are flushing of transfer pumps or jets when the separation distance between the transfer pump/jet suction and the slurried sludge layer meets the requirements of the SCOM Program PDD, flushing of ventilation system components, filling purge condenser seal leg, lifting the evaporator pot to the associated drop tank, and limited duration (5 minutes or less) operation of transfer pump in recirculation in a salt tank. If multiple activities from this list are to be performed (or the same activity is performed multiple times), any previously performed initial hydrogen concentration verification check is considered invalid, and a new check must be performed prior to initiating free supernate removal. The only exception to this involves lifting the evaporator pot to the drop tank. If this activity is in progress when the initial hydrogen concentration verification is performed, then that activity can continue, and one additional activity from the above list (i.e., flushing of transfer pumps or jets, flushing of ventilation system components, filling purge condenser seal leg, or limited duration [5 minutes or less] operation of transfer pump in recirculation in a salt tank) can be performed without invalidating the previous initial hydrogen concentration verification.

- Purge ventilation system has been continuously operating in the waste tanks since the bulk vapor space hydrogen concentration was verified to be less than or equal to 2.5% of the LFL_{25C}.

3. The time to complete an adequate number of vapor space turnovers should be determined based on the best estimate of the actual vapor space volume.

4. The required number of vapor space turnovers for each waste tank shall be determined using WCS [Ref. 11] or an engineering evaluation and documented in the ERD. The methodology used to calculate the number of vapor space turnovers is specified in Reference 15, with a mixing efficiency of 0.2. The mixing efficiency of 0.2 is based on the recommended value from NFPA 69 Annex D for the ventilation system arrangement (single exhaust opening, non-positive supply ventilation system) [Ref. 13].

5. Prior to initiating free supernate removal activities (e.g., waste tank to waste tank transfers, waste tank to outside facility transfers), an engineering evaluation shall be completed to demonstrate that the resultant free supernate hydrogen release rate is less than or equal to the respective limits provided in Table 1. Calculation of the free supernate hydrogen release rate for waste tank to waste tank transfers can be performed in WCS [Ref. 11] as part of the ETAF process. [TSR SAC 5.8.2.29.e]

6. Prior to performing a transfer associated with the Evaporator Feed Pumps (e.g., Tank 32 to 242-25H Evaporator, Tank 43 to 242-16H Evaporator), transfers from waste tanks to outside facilities (e.g., Tank 49 to 512-S, Tank 50 to Saltstone), operations personnel shall verify the activity is approved in the ERD (N-ESR-G-00001).

7. Trapped gas release from slurried sludge may be discounted from the calculation of volume of trapped gas released per inch of free supernate removal provided the following conditions are met:
   - Hydrogen depletion is successfully accomplished in the waste tanks, based on criteria in Section 4.2.1.1.
   - Free supernate removal activities shall be completed within 48 hours upon completion of hydrogen depletion.

8. **If recognition of an unintended saltcake interstitial liquid removal activity has occurred during a free supernate removal activity, then immediately shut down the transfer.**

4.3.2 SLUDGE AGITATION, BULK SALTCAKE DISSOLUTION, AND SALTCAKE INTERSTITIAL LIQUID REMOVAL ACTIVITIES

Hydrogen bubbles can become trapped in the solids layers (i.e., settled sludge, saltcake, and slurried sludge) over time and subsequently released. The amount of trapped hydrogen released is dependent upon the characteristics of the solids layers (e.g., settled sludge or slurried sludge) and the release initiator (e.g, waste tank mixing device operation, hydrostatic head pressure reduction due to free supernate removal, transfer pump operation for the purpose of recirculation).

INSIGNIFICANT SLUDGE MIXING, BULK SALTCAKE DISSOLUTION, AND

SALTCAKE INTERSTITIAL LIQUID REMOVAL ACTIVITIES

Some **operational** activities have the potential to release insignificant amounts of hydrogen (excluding spontaneous liberation events)**. For these activities, a** hydrogen release evaluation **and Gas Release Program controls are not** required. These activities listed below are divided into three categories: sludge agitation, saltcake dissolution, and saltcake interstitial liquid removal. These activities are considered insignificant hydrogen release activities for the specific category identified, but may be considered a significant hydrogen release activity for a different category (or may be considered free supernate removal or a flammable transient concern). Examples of these insignificant hydrogen release activities are provided in the DSA, Section 3.4.2.11.1, and include the following:

- **Sludge Agitation (activity applied to settled and slurried sludge unless otherwise noted)**
  - Rotation of waste tank mixing device turntables
  - Limited duration operation (less than or equal to five minutes) of a waste tank mixing device for operational/maintenance testing (does not apply to a waste tank containing slurried sludge)
  - Sludge sampling
  - Sample rinsing
  - Inserting/removing tank components below the sludge layer (e.g., riser mining tools, pumps, caissons, etc.)
  - Riser mining in a sludge tank
  - Air blowing transfer jets that have a suction below the sludge layer
  - Operating transfer pumps or jets that have a suction below the sludge layer
  - Transfers into the waste tank (regardless of downcomer location)
  - Waste sparging (air or steam)
  - Flushing of transfer pumps or jets
  - Flushing of ventilation system components (e.g., demister, reheater) and level monitoring equipment (e.g., reel tape)
  - Filling purge condenser seal leg

  Sludge agitation activities stated above, if performed in slurried sludge, may cause a spontaneous liberation event; however, no hydrogen release evaluation is required for the activity. Routine Flammability Controls and the Spontaneous Liberation Protection portion of the Waste Tank Quiescent Time Program ensure waste tanks maintain the minimum time to LFL (CLFL for Tank 50) defined by the waste tank flammability classification. These controls are adequate to ensure spontaneous liberation events would not be a concern in these waste tanks.

  In general, if activities in waste storage tanks disturb a localized region of sludge, then these activities are judged to result in an insignificant hydrogen release.

- **Bulk Saltcake Dissolution**
  - Bearing water leaks from pressurized pump columns (e.g., slurry pump, telescoping transfer pump) during transfers into a waste tank
  - Limited duration operation (less than or equal to 5 minutes) of a waste tank mixing device or transfer pump (waste tank recirculation) for operational/maintenance testing
  - Transfers out of a salt tank (including transfers with a siphon break on the transfer pump/jet discharge line)
  - Recirculation to the feed tank from the 242-16H evaporator feed pump
  - Evaporator operations associated with concentrated waste being transferred (siphoning/lifting/pump-outs) to the evaporator drop tank (including concurrent transfers)
  - **Transfers into an evaporator drop tank (Tank 30, Tank 37, and Tank 38 only) with an exposed saltcake mound present (located within a 20 ft radius from the center of the evaporator concentrate receipt riser)**
  - Transfers into salt tanks with exposed salt on cooling coils / exposed salt on waste tank wall (height and base in inches not feet)
  - Flushing of equipment in a salt tank
  - Flushing of ventilation system components (e.g., demister, reheater) and level monitoring equipment (e.g., reel tape)
  - Sample rinsing
  - Salt sampling
  - Removing tank components from below the salt layer
  - Filling purge condenser seal leg

- **Saltcake Interstitial Liquid Removal**
  - Limited duration operation (less than or equal to 5 minutes) of a transfer pump for operational/maintenance testing
  - Transfers out of a tank that expose salt peaks/mounds (height and base in inches not feet)
  - Transfers out of a tank that expose salt on cooling coils

In general, if activities in waste tanks disturb a limited quantity of saltcake (e.g., small salt peaks) or remove interstitial liquid from a limited quantity of saltcake, then these activities are judged to result in an insignificant hydrogen release and are not considered bulk saltcake dissolution, or saltcake interstitial liquid removal activities. However, when performing these activities during salt removal activities, the amount of hydrogen released from these “insignificant release” activities shall be considered in the engineering evaluation.

In addition to the operational activities that have the potential to release insignificant

amounts of hydrogen (described above), hydrogen releases may also be associated with the unintended transitions between certain activities. These unintended transitions may be related to uncertainty in saltcake level determinations used to set the thresholds between free supernate removal and saltcake interstitial liquid removal. These transitions/activities include the following:

- **Unintended transition between free supernate removal and saltcake interstitial liquid removal. This activity is considered to release insignificant additional hydrogen. The controls associated with free supernate removal provide adequate protection for a trapped gas release, and the controls associated with saltcake interstitial liquid removal in Gas Release Program are not required for this unintended transition.**
- **Water or dilute supernate addition onto exposed saltcake after unintended transition between free supernate removal and saltcake interstitial liquid removal. This activity, following the unintended transition, is considered to release insignificant amounts of hydrogen. The controls associated with bulk saltcake dissolution in the Gas Release Program are not required for this activity following the unintended transition.**

4.3.2.1 INITIAL GAS RELEASE EVALUATION FOR SLUDGE AGITATION, BULK SALTCAKE DISSOLUTION, AND SALTCAKE INTERSTITIAL LIQUID REMOVAL ACTIVITIES

Prior to planned sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities, an initial evaluation shall be performed to determine whether entry into the Gas Release Mode will be required. Bulk saltcake dissolution and saltcake interstitial liquid removal activities in Type I/II Acidic Chemical Cleaning Waste Tanks and Type I/II Non-Acidic Chemical Cleaning waste tanks are prohibited. Sludge agitation activities that could exceed Gas Release Criteria are prohibited in Type I/II Non-Acidic Chemical Cleaning waste tanks. Tank 50 is not allowed to enter into Gas Release Mode [Ref. 1]. Tanks in Gas Release Mode are prohibited from receiving Chemical Cleaning transfers [Ref. 6]. **Saltcake interstitial liquid removal activities using a transfer jet that could exceed the Gas Release Criteria below are not permitted.** When this initial evaluation shows that the release of hydrogen due to sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities will not cause the vapor space to exceed the following Gas Release Criteria (accounting for atmospheric breathing only), no specific controls regarding planned trapped gas release activities are required (other than Routine Flammability Controls and Gas Release Program) [Ref. 1]:

- Become flammable in less than 7 days for a Rapid Generation Tank (due to flammable vapor contributions from Isopar® L [Tank 50 only], trace organics, trapped gas release and radiolytic hydrogen generation) [Ref. 1].
- Become flammable in less than 28 days for a Slow Generation Tank (due to flammable vapor contributions from Isopar® L [Tank 50 only], trace organics, trapped gas release and radiolytic hydrogen generation) [Ref. 1].
- Become flammable for a tank classified as a Very-Slow Generation Tank (due to flammable vapor contributions from Isopar® L [Tank 50 only], trace organics, trapped gas release and radiolytic hydrogen generation) [Ref. 1].

- Exceed 60% of the temperature-corrected LFL for hydrogen (due only to trapped gas release)

Tanks may be reclassified, based on the engineering evaluation, to meet the above criteria. For example, an evaluation determines that, for a Slow Generation Tank, the assumed trapped gas release from the planned sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities results in reaching 50% of the LFL_T and the subsequent radiolytic hydrogen production causes the tank to become flammable in 25 days. In this case, the tank would exceed the criteria above unless it is reclassified as a Rapid Generation Tank (with the associated Routine Flammability Controls and Gas Release Program).

Tank 26 waste removal performed its first CSMP mixing campaign in February 2019. A sludge sounding performed following a 10-day mixing campaign of all four CSMPs indicated the sludge was disturbed lower in the tank than was expected (i.e., a 32.4-inch disturbance depth versus the 24-inch DSA disturbance depth input). A review of Tank 26 process history indicated that the tank served as the 242-16F evaporator feed tank and canyon receipt tank, having a history of containing highly concentrated supernate, resulting in a waste layer containing a mixture of salt and sludge [Ref. 60, Action 4]. For waste tanks with the potential to contain inter-mixed sludge/salt waste layers, the more conservative waste layer should be assumed for gas release and quiescent time evaluations **[Ref. 61]**.

4.3.2.2 GAS RELEASE METHODOLOGY FOR SLUDGE AGITATION, BULK SALTCAKE DISSOLUTION, AND INTERSTITIAL LIQUID REMOVAL ACTIVITIES

VARIABLE H2 TOTAL CALCULATION – INITIAL GRM EVALUATION

The hydrogen concentration due to trapped gas release is added to the initial concentration to determine the total hydrogen concentration, H_2Total, in the waste tank vapor space due to sludge agitation, bulk saltcake dissolution or interstitial liquid removal activities:

Eq. #86 $H_2Total = H_2Initial + TG$

Where:

H2Total	=	Total hydrogen concentration in the waste tank vapor space due to sludge agitation, bulk saltcake dissolution or interstitial liquid removal, vol. frac.
H_2Initial	=	Initial hydrogen concentration, vol. frac. (see Variable H_2Initial Calculation)
TG	=	Hydrogen concentration due to trapped gas release (see Variable TG Calculation), vol. frac.

VARIABLE H_2INITIAL CALCULATION – INITIAL GRM EVALUATION

An adequate number of vapor space turnovers (and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration) establishes the initial hydrogen

concentration in the tank vapor space as low as practical when desired. This assumes that the tank is under conditions that do not cause significant hydrogen release (e.g., no incoming jetted transfers or sludge agitation activities) and accounts for radiolytic hydrogen generation. Vapor space turnovers (and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration) are not required for the insignificant sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities listed in Section 4.3.2 or when the steady state hydrogen equilibrium concentration is used as the initial hydrogen concentration (e.g., for Very Slow Generation Tanks). The time to complete an adequate number of vapor space turnovers is determined based on the best estimate of the actual vapor space volume.

Flammability evaluations shall use the maximum of 2.5% of the LFL_{25C} for hydrogen or a value based on the steady state hydrogen equilibrium concentration accounting for ventilation operation ($H_{eq(Rapid/Slow)}$) as the initial condition for Rapid and Slow Generation Tanks. A value greater than 2.5% of the LFL_{25C} may be used as the initial condition; however, this value may not be less than 2.5% of the LFL_{25C}. The steady state hydrogen equilibrium concentration is calculated using Equation 87, substituting the atmospheric breathing term, Q_{ATM}, with the DSA minimum purge ventilation flow rate (minimum required purge flow for the applicable flammability classification). This value is compared to 2.5% of the LFL_{25C} and the greater of the two is used as H_2Initial in Equation 86. If $H_{eq(Rapid/Slow)}$ is used, it should be increased by an appropriate amount to balance the allowable trapped gas release against the number of vapor space turnovers required, as determined by an engineering evaluation.

For Very Slow Generation Tanks, the greater of 2.5% of the LFL_{25C} or H_{eq}, accounting for atmospheric breathing only (see Equation 88), can be used as the initial hydrogen concentration if the calculated trapped gas release does not cause the tank vapor space to exceed the LFL_{OC}. No vapor space turnovers are required for the initial trapped gas release activity if the greater of 2.5% of the LFL_{25C} or H_{eq} is used as the initial condition for Very Slow Generation Tanks. For each subsequent trapped gas release activity (e.g., after a pump is lowered), vapor space turnovers (and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration) shall be required to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to the initial hydrogen concentration assumed in the hydrogen release engineering evaluation. If H_{eq} is greater than 2.5% of the LFL_{25C} and using H_{eq} as the initial hydrogen concentration causes the waste tank vapor space to exceed 100% of the LFL_{OC} upon releasing the trapped hydrogen, 2.5% of the LFL_{25C} may be used as the initial hydrogen concentration; however, vapor space turnovers or hydrogen monitoring shall be required prior to each trapped gas release activity to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to 2.5% of the LFL_{25C}.

The required number of vapor space turnovers for each tank will be documented in the ERD [Ref. 2]. The methodology specified in Reference 15 with a mixing efficiency of 0.2 shall be employed to determine the adequate number of vapor space turnovers. The mixing efficiency of 0.2 is based on the recommended value from NFPA 69 Annex D for the ventilation system arrangement (single exhaust opening, non-positive supply ventilation system) [Ref. 13]. However, vapor space turnovers and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration can be employed to ensure that the waste tank bulk vapor space hydrogen concentration is less than or equal to the initial value assumed in the hydrogen

release engineering evaluation. If the latter option is used (not applicable to Tank 50), the methodology to determine the flammable vapor concentration shall be consistent with the requirements of Reference 7. Because the initial hydrogen concentration for Tank 50 cannot be measured, and hydrogen monitoring is not required for Tank 50, vapor space turnovers will be performed in Tank 50, when classified as a Rapid or Slow tank, to reduce the initial hydrogen concentration from 3.8% of the LFL_T to the higher of 2.5% of the LFL_{25C} or $H_{eq(Rapid/Slow)}$. As a Very Slow waste tank, vapor space turnovers can be used in Tank 50 to reduce the equilibrium concentration to 2.5% of the LFL_{25C} if necessary. Vapor space turnover requirements for Tank 50, when necessary, will have to be met by ACTUAL vapor space turnovers, using the calculation in the ERD [Ref. 2] to determine the "Ventilation Time (hr)" to achieve this.

VARIABLE H_{EQ} CALCULATION – INITIAL GRM EVALUATION

For Rapid and Slow Generation Tanks, steady state hydrogen equilibrium accounting for ventilation (minimum required purge flow for the applicable flammability classification) may be used as the assumed initial hydrogen concentration prior to initiation of sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities. The steady state hydrogen equilibrium ($H_{eq\ (Rapid/Slow)}$) is calculated using the following equation:

Eq. #87 $$H_{eq\ (Rapid/Slow)} = \frac{Q_{H2}}{Q_{H2} + 60 \cdot Q_{purge}}$$

Where:

$H_{eq\ (Rapid/Slow)}$	=	Hydrogen concentration at equilibrium accounting for minimum ventilation flow rate, vol. frac.
Q_{H2}	=	Total hydrogen volumetric evolution rate, ft^3/hr (see Variable Q_{H2} in Section 4.1.2.2.1)
Q_{purge}	=	Minimum purge flow rate, ft^3/min
	=	72 ft^3/min for Rapid tanks; 45 ft^3/min for Slow tanks
60	=	Conversion factor from hours to mins

For Very Slow Generation Tanks, steady state hydrogen equilibrium accounting for atmospheric breathing may be used as the assumed initial hydrogen concentration prior to initiation of sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities based on the requirements in the Variable H_2Initial Calculation Section and is calculated using the expression below:

Eq. #88 $$H_{eq} = \frac{Q_{H2}}{Q_{H2} + Q_{ATM}}$$

Where:

H_{eq}	=	Hydrogen concentration at equilibrium, vol. frac.
Q_{H2}	=	Total volumetric hydrogen generation rate, ft^3/hr (see Variable Q_{H2} Calculation in Section 5.1.2.2.1)

Q_{ATM}	=	Atmospheric breathing rate, ft³/hr (see Variable Q_{ATM} Calculation)

VARIABLE Q_{ATM} CALCULATION – INITIAL GRM EVALUATION

The atmospheric breathing assumptions and methodology are established in Reference 1 Section 3.4.1.5.5. The atmospheric breathing rate is determined as follows:

Eq. #89 $$Q_{ATM} = \frac{\text{mean atm.fluctuation}}{1013} * \frac{V_V}{24}$$

Where:

Q_{ATM}	=	Atmospheric breathing rate, ft^3/hr
Mean atm. fluctuation	=	Mean pressure fluctuation, 5 mbar/day [Ref. 41]
V_V	=	Vapor space volume, based on the HLLCP setpoint, ft³ (see Variable V_v Calculation)
24	=	Conversion factor from days to hours
1013	=	Standard atmospheric pressure, mbar

VARIABLE V_V CALCULATION – INITIAL GRM EVALUATION

The HLLCP shall be used to protect the vapor space volume in the initial evaluation for sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities to determine if entry into Gas Release Mode will be required. **For saltcake interstitial liquid removal activities, the vapor space volume may also be based on the actual waste contents/inventory.** The following equation is the vapor space volume calculation in units of ft^3.

Eq. #90 $$V_V = 0.13368\,[V_T - (L_{HLLCP} + IU) * Ff - MMW\,]$$

Where:

V_v	=	Vapor space volume**, ft³ ,** based on the HLLCP setpoint**. For saltcake interstitial liquid removal, the vapor space volume may also be based on the actual/projected waste tank level.**
V_T	=	Total tank vapor space volume (empty tank), gallons
L_{HLLCP}	=	Level of HLLCP setpoint**, inches. For saltcake interstitial liquid removal, actual/projected waste level may be used.**
Ff	=	Nominal waste tank fill factor, gal/in (see Section 3.0)
MMW	=	Maximum volume associated with a Transfer Error event, equal to 15,000 gallons **for sludge agitation and bulk saltcake dissolution. For saltcake interstitial liquid removal, MMW is considered to be zero.**

IU	=	Uncertainty attributed to HLLCP, inches [see Ref. 12]. **For saltcake interstitial liquid removal using actual/projected waste level, this value is zero.**
0.13368	=	Conversion factor from gallons to ft^3

Actual/projected waste level may be used to credit the vapor space volume when calculating trapped gas release during saltcake interstitial liquid removal. The waste level could be the tank level prior to free supernate removal activity (actual level) or the level of the bulk saltcake plus some margin (projected level) to account for uneven saltcake layer or a layer of supernate on top of the saltcake. However, it must be adjusted to account for any salt peaks/mounds with height and base in feet not inches. The hydrostatic head pressure of the waste layers between the actual/projected waste level and the bulk saltcake level must be included in the total head pressure calculations (see Variable C Calculation – Initial GRM Evaluation).

VARIABLE TG CALCULATION – INITIAL GRM EVALUATION

The methodology for determining the vapor space hydrogen concentration due to trapped gas release from sludge agitation or bulk saltcake dissolution is provided below. Each contributing phase (i.e., trapped gas release from saltcake, trapped gas release from settled sludge, and trapped gas release from slurried sludge) shall have a separate value of trapped hydrogen gas released (TG) and these values are added together to determine the total trapped gas release.

Eq. #91 $$TG = \frac{V_{solids} \cdot H_{mix} \cdot C \cdot G_S \cdot F_R}{V_V}$$

Where:

TG	=	Trapped hydrogen released due to sludge agitation and/or bulk saltcake dissolution activities, vol. frac.
V_{solids}	=	Volume of solids layer that is available to liberate hydrogen, ft^3 (see Variable V_{solids} Calculation)
G_s	=	Fraction of trapped bubble gas in solids layers that is available to liberate hydrogen, vol. frac. (see Variable G_s Calculation)
H_{mix}	=	Hydrogen fraction in trapped gas, vol. frac. (see Variable H_{mix} Calculation)
C	=	Pressure correction factor (see Variable C Calculation)
F_R	=	Fraction of trapped gas release, vol. frac. (see Variable F_R Calculation)
V_v	=	Vapor space volume protected by HLLCP, ft^3 (see Variable V_v Calculation)

For waste tanks containing an overlying settled sludge/slurried sludge layer above a saltcake layer and/or a slurried sludge layer beneath the saltcake layer, operating a transfer pump in recirculation may have the potential to release the hydrogen gas trapped in the sludge layers. When sludge layers exist above the saltcake, bulk saltcake dissolution from recirculation of the transfer pump is considered to have the potential to disturb any overlying sludge layers as the supporting saltcake beneath is dissolved. Additionally, dissolving saltcake is conservatively assumed to have the potential to disturb the slurried sludge below the saltcake layer by initiating a spontaneous release. The release of the hydrogen gas trapped in the sludge layers is assumed to be an instantaneous release of 100% of the trapped gas from the sludge. Therefore, the volume of trapped hydrogen gas in the overlying settled sludge/slurried sludge above the saltcake layer and/or the slurried sludge layer beneath the saltcake layer shall be included in the total trapped hydrogen gas released during operation of transfer pump in recirculation in a waste tank containing saltcake [Ref. 43].

For saltcake interstitial liquid removal, removing saltcake interstitial liquid will not only release trapped hydrogen gas from saltcake where the interstitial liquid is removed but also release trapped hydrogen gas from the solids layers below the pump/**jet** suction due to reduction of hydrostatic head over the trapped hydrogen gas within these solids layers. The volume of trapped hydrogen gas release per inch of interstitial liquid removal for each applicable solids layer beneath the pump suction is calculated in the same manner as the volume of trapped hydrogen gas release per inch of free supernate removal (see Equation 84). Combining Equation 84 into Equation 91 and accounting for the volume of interstitial liquid removed, the total volume of trapped gas released due to saltcake interstitial liquid removal is simplified as follows:

Eq. #92
$$TG = \frac{H_{mix}}{V_V}\left[V_{salt}.C.G_S.F_R + \frac{(0.0254).(0.13368)}{1.01325E+05}.\frac{\rho.g.L_{liquid}}{P_{atm}}.\sum_{1}^{n}\left(V_{solids_pump}.G_S\right)_n\right]$$

Where:

TG	=	Trapped hydrogen released due to saltcake interstitial liquid removal, vol. frac.
V_{salt}	=	Volume of saltcake layer above the pump/**jet** suction, ft³ (see Variable V_{solids} Calculation)
G_s	=	Fraction of trapped bubble gas in applicable solids layers, vol. frac. (see Variable G_s Calculation)
H_{mix}	=	Hydrogen fraction in trapped gas, vol. frac. (see Variable H_{mix} Calculation)
C	=	Pressure correction factor (see Variable C Calculation)
F_R	=	Fraction of trapped gas release, vol. frac. (see Variable F_R Calculation)
V_v	=	Vapor space volume protected by HLLCP, ft³ (see Variable V_v Calculation)
0.0254	=	Conversion factor from inches to meters
1.01325E+05	=	Conversion factor from atms to Pas (N/m^2)

0.13368	=	Conversion factor from gallons to ft^3
ρ	=	Density of interstitial liquid , kg/m^3
g	=	Standard acceleration of gravity (9.81 m/s^2)
P_{atm}	=	Ambient pressure, atm
L_{liquid}	=	Height of interstitial liquid removed, inches
V_{solids_pump}	=	Volume of solids layers below the pump/**jet** suction, gallons
n	=	Number of solids layers below the pump/**jet** suction

VARIABLE V_{SOLIDS} CALCULATION – INITIAL GRM EVALUATION

All insoluble solids are considered to retain trapped gas for the purposes of trapped gas retention. The DSA, Section 3.4.1.5.3 and References 32, 41 and 49 establish the inputs for determining the volume of solids affected due to sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities.

- **Sludge Agitation**
  - Settled sludge:
    - If the agitation source is a single SMP, multiple slurry pumps, multiple quad-volutes, multiple SBPs, or multiple CSMPs, the volume of sludge affected is 100% of the tank cross sectional area (accounting for sludge disturbance depth)
    - If the agitation source is a single slurry pump, single quad-volute slurry pump, single SBP, or single CSMP, the volume of sludge affected is 50% of the tank cross sectional area (accounting for sludge disturbance depth).
    - The settled sludge disturbance depth for releasing trapped gas is the sludge 24 inches below the bottom of the waste tank mixing device and the entire depth of the sludge above the bottom of the mixing device for all pumps but the quad-volute slurry pumps. The quad-volute slurry pumps release the entire depth of sludge regardless of the installation height.
  - Slurried sludge: The volume of sludge affected is 100% of the slurried sludge inventory, even if the agitation source is a single waste tank mixing device.

- **Saltcake removal activities**

  The trapped hydrogen gas released due to bulk saltcake dissolution is equivalent to the hydrogen gas trapped in the volume of saltcake dissolved. Reference 54 demonstrates that at a temperature less than or equal to 70^0C, the ratio of dissolution by volume between liquid and salt is bounded by 1:1.

  For bulk saltcake dissolution, the amount of saltcake dissolved in the affected tank is equal to the smaller of the total volume of saltcake in the waste tank or the volume of the liquid which will be used for bulk saltcake dissolution. If a liquid source tank is to be used for bulk saltcake dissolution and the volume of the tank is used to estimate the volume of saltcake

dissolved, the liquid source must not have the capability for continuous makeup. The liquid source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrically or mechanically isolated. The electrical or mechanical isolation shall contain two independent means of isolation (e.g., two isolation valves; one isolation valve and open disconnect for liquid source transfer pump). For example, a dissolution water skid (DWS) is commonly used as a method for introducing water into a waste tank for saltcake dissolution. The liquid source system for the DWS contains solenoid actuated valves, controlled by a Programmable Logic Controller (PLC), that mechanically isolate the system from the continuous water source. The solenoid actuated valves and PLC controller have been shown to be extremely robust in flow isolation capabilities. A failure of the PLC causing continuous makeup flow is considered not to exist [Ref. 1, Section 3.4.1.5.2.6].

For interstitial liquid removal, the amount of saltcake available to liberate hydrogen in the affected tank is the volume of saltcake above the pump/**jet** suction elevation. The pump/**jet** suction elevation must be defined by a technical baseline document governing the pump/**jet** installation.

For saltcake dissolution with mixing devices, trapped gas release is encompassed by dissolution of saltcake rather than by mechanical agitation of the salt, and therefore volume disturbed by a mixing device (as defined by cross-sectional area and disturbance depth) is not applicable for determining trapped hydrogen release.

The volume of saltcake dissolved varies depending on the liquid addition methods and the layer of liquid above the bulk saltcake and is discussed below. Dissolution ratios are valid for supernate temperatures less than or equal to 70°C unless otherwise noted.

- Saltcake With No Supernate Coverage: For saltcake dissolution due to liquid addition to saltcake with no supernate coverage, the trapped hydrogen released is equivalent to the gas trapped in the volume of saltcake dissolved, where:
  - 1 gallon of water added dissolves 1 gallon of saltcake.
  - 1 gallon of dilute supernate added dissolves 1 gallon of saltcake.
  - Addition of concentrated supernate results in insignificant salt dissolution.

- Saltcake With Supernate Coverage: For saltcake dissolution due to liquid addition to saltcake with supernate coverage, the trapped hydrogen released is equivalent to the gas trapped in the volume of saltcake dissolved, where:
  - If supernate coverage over the **bulk** saltcake **layer is dilute supernate and** has been present for less than or equal to 4 days or if concurrent additions are made at more than one location (e.g., riser, downcomer), then adding 1 gallon of water or dilute supernate dissolves 1 gallon of saltcake. Addition of concentrated supernate (under the same conditions) results in insignificant saltcake dissolution.
  - If supernate coverage over the **bulk** saltcake **layer is concentrated supernate or** has been present for greater than 4 days, any addition of water, dilute supernate, or concentrated supernate, regardless of the location of the point of entry of the incoming liquid (e.g., in the vapor space, in the supernate or in the saltcake), results

in insignificant saltcake dissolution. This allowance does not apply for concurrent additions at more than one location (e.g., riser, downcomer). This input is not dependent on temperature.

- Saltcake Dissolution With Waste Tank Mixing Devices: For saltcake dissolution due to waste tank mixing devices, the trapped hydrogen released is equivalent to the gas trapped in the volume of saltcake dissolved, where:
  - 1 gallon of liquid in the tank above the bulk saltcake layer, whether the tank contains dilute supernate or concentrated supernate, dissolves 1 gallon of saltcake.
  - 1 gallon of any liquid being introduced (e.g., dissolution water) dissolves 1 gallon of saltcake.

- Saltcake Dissolution With Mixing Eductors: Mixing eductors are designed to promote saltcake dissolution via convective mixing. This is accomplished by discharging the water added through a nozzle, entraining the liquid above the waste tank bulk saltcake layer through an eductor assembly at a ratio of 4 gallons of the waste tank liquid to 1 gallons of water added. At the start of a dissolution campaign and after a mixing eductor is lowered to improve convective mixing, the volume of liquid present in the tank above the bulk saltcake layer may dissolve saltcake. Therefore, the volume of liquid present above the bulk saltcake layer, in addition to the volume of water being added, must be accounted for in the 1:1 salt dissolution ratio assumed in the calculation for hydrogen release until the entire volume of that material is entrained through a mixing eductor at the design entrainment ratio between tank liquid and additional water of 4:1 (i.e., 4 volumes of tank liquid plus 1 volume of water added dissolves 5 volumes of bulk saltcake). For subsequent water additions to the waste tank at the same eductors elevation or if the mixing eductors are raised, the volume of liquid above the bulk saltcake layer does not need to be accounted for since the liquid has already acted as a saltcake dissolution media. Only the liquid added via the mixing eductors will dissolve saltcake at a 1:1 ratio.

In summary, for salt dissolution associated with mixing eductors, the trapped hydrogen released is equivalent to the gas trapped in the volume of saltcake dissolved, and is dependent upon the following:

- Water added through a mixing eductor at the start of a dissolution campaign and after a mixing eductor is lowered dissolves saltcake at the following ratio, until the total volume of water added through the mixing eductor(s) equals ¼ of the liquid volume initially above the Bulk Saltcake Layer:
  - 1 gallon of water added dissolves 5 gallons of saltcake (1 gallon of saltcake dissolved for each gallon added, plus 4 gallons of saltcake dissolved due to the mixing of the liquid in the tank, whether the tank contains Dilute Supernate or Concentrated Supernate).
- After the total volume of water added through the mixing eductor(s) equals ¼ of the liquid volume initially above the Bulk Saltcake Layer, subsequent water additions through a mixing eductor at the same eductor(s) elevation or if the mixing eductor(s) are raised dissolve saltcake at the following ratio:
  - 1 gallon of water added dissolves 1 gallon of saltcake

- Saltcake Dissolution With Transfer Pump Operated for the Purpose of Recirculation: Recirculation with a transfer pump is defined as the planned movement of waste tank contents through a flow path (which may or may not be exclusively internal to the waste tank) that concludes with the bulk of the material being returned to the same waste tank. Flow that returns to the waste tank through an engineering feature (such as a siphon break in the transfer line) or minor leakage from valves, fittings, etc. is not considered recirculation, as long as the bulk of the material is being removed from the waste tank. Operation of a waste tank pump in recirculation (i.e., discharging existing waste tank liquid back into the same waste tank) of dilute supernate is conservatively assumed to dissolve saltcake. Therefore, for saltcake dissolution due to transfer pump operation for the purpose of waste tank recirculation, the trapped hydrogen released is equivalent to the gas trapped in the volume of saltcake dissolved, where:
  - 1 gallon of dilute supernate in the tank above the bulk saltcake layer dissolves 1 gallon of saltcake.
  - Waste tank recirculation of concentrated supernate results in insignificant saltcake dissolution.

VARIABLE G_S CALCULATION – INITIAL GRM EVALUATION

As documented in the DSA, Section 3.4.1.5.3, the maximum percentage of trapped bubble gas in saltcake, settled sludge and slurried sludge is as follows:

- 11% by volume in saltcake
- 10% by volume in settled sludge
- 20% by volume in slurried sludge

VARIABLE H_{MIX} CALCULATION – INITIAL GRM EVALUATION

In waste tanks with known chemistry and heat loads, H_{mix} may be determined using equations documented in Section 4.1.2.2.2, limited to a maximum of 75%. Otherwise, the hydrogen percent in trapped gas is:

- 75% in waste tanks that contain slurried sludge
- 50% in other waste tanks

For sludge and/or salt tanks where water or inhibitor is added, the time for the water or inhibitor to diffuse into the interstitial liquid (5-10 years depending on particle size, density gradients and temperature gradients) is considered so long that the percent hydrogen in trapped gas is assumed to be unchanged; therefore, current chemistry (i.e., chemistry prior to the water/inhibitor addition) may be used to determine the hydrogen concentration in trapped gas for Gas Release evaluations [Ref. 16].

VARIABLE C CALCULATION – INITIAL GRM EVALUATION

The expansion factor is used for predicting the effect of pressure on trapped bubble gas release due to sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities.

The relationship between the expansion factor and the head pressure is linear ($C = P_{avg}/P_{atm}$). The expansion correction is determined from the following head pressure equation [Ref. 14]:

Eq. #93
$$P_{avg} = \left(\sum_{a=2}^{n} \frac{\rho_a . g . h_a}{X} \right) + \frac{1}{2} \frac{\rho_1 . g . h_1}{X} + p_{atm}$$

Where:

P_{avg}	=	Hydrostatic head pressure, atm
n	=	Number of layers in the waste tank above the evaluated layer
ρ_a	=	Density of layer material, kg/m³
ρ_1	=	Density of the evaluated layer material, kg/m³
h_a	=	Height of layer, m
h_1	=	Height of the portion of the evaluated layer from which hydrogen can be released, m
g	=	Standard acceleration of gravity (9.81 m/s^2)
p_{atm}	=	Atmospheric pressure, atm
X	=	101325 Pa/atm, conversion factor from Pa to atm

Actual/projected waste level may be used to credit the vapor space volume when calculating trapped gas release during saltcake interstitial liquid removal. The head pressure of the waste layers between the actual/projected waste level assumed as the initial level in the GRM evaluation for interstitial liquid removal and the saltcake level must be accounted for in the total head pressure calculation. For example,

If the assumed initial level is the tank level prior to free supernate removal activity, the hydrostatic head pressure exerted by the free supernate layer must be included in the total head pressure calculation.

If the assumed initial level is the level of the bulk saltcake plus some margin to account for uneven saltcake layer or a layer of supernate on top of the saltcake, the hydrostatic head pressure exerted by the liquid layer within the margin must be accounted for in the total head pressure calculation.

VARIABLE F_R CALCULATION – INITIAL GRM EVALUATION

The percentage of trapped hydrogen gas release is assumed to be 100%.

4.3.2.3 GAS RELEASE MODE SLUDGE AGITATION, BULK SALTCAKE DISSOLUTION, AND SALTCAKE INTERSTITIAL LIQUID REMOVAL ACTIVITIES

For planned sludge agitation, bulk saltcake dissolution, or saltcake interstitial liquid removal activities where the percent LFL (initial hydrogen concentration plus trapped gas release) could exceed the SAV (or 60% of the LFL_T for trapped gas release from Very Slow Generation Tanks) or the minimum time to LFL is not met for the applicable flammability classification of the waste

tank, based on the guidelines presented for the initial evaluation, GRM shall be declared for the waste tank prior to sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities. Once the waste tank has entered GRM, the waste tank sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities shall be controlled to maintain the waste tank bulk vapor space hydrogen concentration less than or equal to the SAV and the minimum time to LFL defined by the waste tank flammability classification. The methodology used to determine the necessary controls (e.g., number of waste tank mixing devices and mixing device speed/indexing [for sludge agitation], amount/rate of liquid addition and recirculation pump flow rate [for bulk saltcake dissolution], amount/rate of saltcake interstitial liquid removal transfer pump flow rate [saltcake interstitial liquid removal]) shall be based on an individual engineering evaluation and shall consider the solids layers (saltcake, settled sludge, and slurried sludge) that are affected by the activity. The trapped gas release evaluation shall be based on the actual waste contents/inventory (considering incoming transfers), minimum required ventilation flow rate for waste tanks (72 scfm for all waste tanks except Tanks 40 and 51 [188 scfm]). The calculated time to LFL shall be based on the vapor space volume protected by the HLLCP setpoint. Consideration should also be given to the resulting GRM Quiescent Time for a waste tank in GRM if slurried sludge is created. The methodology used for the GRM evaluation is similar to the methodology discussed in Section 4.3.2.2, except as follows:

- Sludge Agitation Activities
  - Trapped hydrogen gas release percentage: The evaluation may be based on controlled parameters (e.g., number of waste tank mixing devices, mixing device speed/indexing) to determine the affected tank cross sectional area and sludge disturbance depth.

  - Actual waste height: Actual/projected waste tank level may be used to credit the waste tank vapor space volume when calculating trapped gas released. For waste tanks receiving transfers, the actual waste level shall be adjusted to account for the planed transfer amount and does not have to be adjusted for the maximum volume associated with a Transfer Error event (i.e., 15,000 gallons).

- Saltcake Removal Activities
  - Volume/amount of saltcake for bulk saltcake dissolution due to liquid addition with or without supernate coverage, except when performed via mixing eductors: The evaluation may be based on controlled parameters (e.g., amount/rate of liquid addition) to determine the saltcake volume and affected dissolution rate and corresponding hydrogen release rate for the activity using the 1:1 saltcake dissolution ratio between liquid (water/dilute supernate) and salt. This hydrogen release rate may be then used to calculate the time dependent hydrogen concentration accumulated in the waste tank vapor space rather than assuming an instantaneous hydrogen release from the total volume of saltcake.

  - Volume/amount of saltcake for bulk saltcake dissolution for liquid addition via mixing eductors with or without supernate coverage: The evaluation may be based on controlled parameters (e.g., amount/rate of liquid addition) to determine the saltcake volume and affected dissolution rate (and corresponding hydrogen release rate) for this activity. The evaluation shall be performed in accordance with the methodology described in Reference 59. The resulting hydrogen release rate may then be used to calculate the time

dependent hydrogen concentration accumulate in the waste tank vapor space rather than assuming an instantaneous hydrogen release from the total volume of saltcake.

- Volume/amount of saltcake for bulk saltcake dissolution due to transfer pump waste tank recirculation: The evaluation may be based on controlled parameters (e.g., transfer pump/recirculation flow rate) to determine the saltcake volume and affected dissolution rate and corresponding hydrogen release rate for the activity using the 1:1 dissolution ratio between liquid (water/dilute supernate) and salt. This hydrogen release rate may then be used to calculate the time dependent hydrogen concentration accumulated in the waste tank vapor space rather than assuming an instantaneous hydrogen release from the total volume of saltcake.

  For waste tanks containing an overlying settled sludge/slurried sludge layer above a saltcake layer and/or a slurried sludge layer beneath the saltcake layer, operating a transfer pump in recirculation may have the potential to release the hydrogen gas trapped in the sludge layers. When sludge layers exist above the saltcake, bulk saltcake dissolution from recirculation of the transfer pump is considered to have the potential to disturb any overlying sludge layers as the supporting saltcake beneath is dissolved. Additionally, dissolving saltcake is conservatively assumed to have the potential to disturb the slurried sludge below the saltcake layer by initiating a spontaneous release. Therefore, the release of hydrogen gas trapped in the sludge layers is assumed to be an instantaneous release of 100% of the trapped gas from the sludge and will be included in the assumed initial hydrogen concentration [Ref. 43].

- Volume/amount of saltcake for bulk saltcake dissolution due to waste tank mixing device operation: The evaluation may be based on controlled parameters (e.g., number of waste tank mixing devices, mixing device speed/indexing) to determine the saltcake volume and affected dissolution rate (and corresponding hydrogen release rate) for this activity. The evaluation shall be performed in accordance with the methodology described in Reference 59. The resulting hydrogen release rate may then be used to calculate the time dependent hydrogen concentration accumulated in the waste tank vapor space rather than assuming an instantaneous hydrogen release from the total volume of saltcake.

- Volume/amount of saltcake for saltcake interstitial liquid removal: The evaluation may be based on controlled parameters (e.g., saltcake interstitial liquid removal transfer pump flow rate) to determine the saltcake volume and affected hydrogen release rate for the activity. This hydrogen release rate may be then used to calculate the time dependent hydrogen concentration accumulated in the waste tank vapor space rather than assuming an instantaneous hydrogen release from the total volume of saltcake.

- Actual waste height: Actual/projected waste tank level may be used to credit the waste tank vapor space volume when calculating trapped gas release. For waste tanks receiving transfers, the actual waste level shall be adjusted to account for the planed transfer amount and does not have to be adjusted for the maximum volume associated with a Transfer Error event (i.e., 15,000 gallons).

Using controlled parameters to modify the inputs stated above (e.g., actual waste height) is considered acceptable given the waste tank in GRM with associated level of controls (e.g., exhaust low flow/high hydrogen concentration interlocks) and continued use of conservative trapped gas release inputs (e.g., bubble gas fraction, hydrogen percent in trapped gas) in the evaluation. In lieu of using the actual waste contents/inventory, the evaluation may be based on the vapor space volume protected by the Tank Fill Limits Program.

When an activity affects multiple solids layers (e.g., waste tank mixing device operation resulting in settled sludge agitation and bulk saltcake dissolution), the engineering evaluation may utilize more than one of the modified inputs/methodologies stated above (based on controlled parameters).

4.3.2.4 IMPLEMENTATION ACTIONS

1. Prior to initiation of sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities, an engineering evaluation shall be performed to determine whether entry into the Gas Release Mode will be required [TSR SAC 5.8.2.29.a]**. Additionally, if an unintended saltcake interstitial liquid removal has occurred, subsequent interstitial liquid removal activities or water/dilute supernate additions to exposed saltcake shall require an engineering evaluation to determine whether entry into the Gas Release Mode will be required.**

2. Operating procedures shall address the requirement to perform an adequate number of vapor space turnovers and/or verifying vapor space hydrogen concentration prior to planned trapped gas release activities to ensure the waste tank bulk vapor space hydrogen concentration is less than the initial value assumed in the hydrogen release engineering evaluation. Operating procedures shall address the requirement to have second person verification of completion of vapor space turnover time and/or comparison of the hydrogen concentration reading to the hydrogen concentration acceptance value. If verifying the vapor space hydrogen concentration (i.e., comparing the tank LFL reading to a reading obtained using a known LFL concentration) is implemented, the methodology used to determine the flammable vapor concentration shall be consistent with the requirements of Reference 7. [TSR SAC 5.8.2.29.b & TSR SAC 5.8.2.29.d]

3. For sludge agitation activities, the GRM evaluation shall account for water additions that will be used prior to or during waste tank mixing device operation (e.g., SMP flushing, slurry pump bearing water inleakage).

4. During bulk saltcake dissolution or saltcake interstitial liquid removal activities, the amount of hydrogen released from associated insignificant release activities shall be considered in the GRM evaluation for bulk saltcake dissolution or saltcake interstitial liquid removal activities.

5. For waste tanks undergoing sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities, the GRM evaluation shall determine the number of vapor space turnovers required to reduce the waste tank bulk vapor space hydrogen concentration to less than or equal to the initial value assumed in the hydrogen release engineering evaluation.

The number of vapor space turnovers shall be documented in the ERD.

Vapor space turnovers and/or comparing the tank LFL reading to a reading obtained using a known LFL concentration are not required for the following activities:

- Insignificant sludge mixing, bulk saltcake dissolution or saltcake interstitial liquid removal activities, when performed as a stand-alone activity.
- Initial trapped gas release activities in Very Slow Generation Tanks, since the initial hydrogen concentration in the Gas Release evaluation is assumed to be equal to the maximum of 2.5% of the LFL_{25C} or the equilibrium hydrogen concentration. For each subsequent trapped gas release activity (e.g., after a pump is lowered, dissolution batch is added to the tank), vapor space turnovers and/or verifying vapor space hydrogen concentration shall be required to ensure the waste tank bulk vapor space hydrogen concentration is less than or equal to the initial value assumed in the evaluation.

6. Operating procedures shall address all the parameters (e.g., mixing device speed/indexing, number of waste tank mixing devices, transfer pump/recirculation pump flow rate, HLLCP setpoint) assumed in the hydrogen release evaluation prior to initiation of sludge agitation, bulk saltcake dissolution or saltcake interstitial liquid removal activities.

7. Planned operation (e.g., waste tank to waste tank transfers) shall be pre-evaluated to ensure bulk saltcake dissolution does not occur for the affected process areas (e.g., receiving tanks) as part of the ETAF process [Ref. 11, Tab Electronic SW11.1], without an engineering evaluation (excluding Insignificant Saltcake removal activities listed in Section 4.3.2).

8. Planned operations (e.g., waste tank to waste tank transfers) shall be pre-evaluated to ensure interstitial liquid removal does not occur for the affected process areas (e.g., sending tanks) as part of the ETAF process [Ref. 11, Tab Electronic SW11.1], without an engineering evaluation.

9. Liquid additions to the waste tanks shall be pre-evaluated using WCS [Ref. 11] or an engineering evaluation (excluding Insignificant Saltcake removal activities listed in Section 4.3.2 and excluding planned saltcake removal activities which require a separate engineering evaluation) to ensure bulk saltcake dissolution does not occur from dissolution of exposed bulk salt in the receipt tank.

10. Bulk saltcake dissolution and interstitial liquid removal activities in Type I/II Acidic Chemical Cleaning Waste Tanks and Non-Acidic Chemical Cleaning Waste Tanks are prohibited.

11. Prior to operation of a waste tank mixing device in a waste tank containing only slurried sludge (for a waste tank mixing device that has not been operated within 180 days), operating procedures shall address the requirements to verify that the waste tank level is less than or equal to the associated Waste Tank Level Limitations for Flammable Transient provided in Table 2 and to have second person verification of waste tank level. [TSR SAC 5.8.2.29.f]

12. Prior to operation of a waste tank mixing device in a waste tank containing saltcake, settled sludge, or any combination of saltcake, settled sludge, or slurried sludge, operating

procedures shall address the requirements to verify that the waste tank level is less than or equal to the associated Waste Tank Level Limitations for Flammable Transient provided in Table 3 and to have second person verification of waste tank level. [TSR SAC 5.8.2.29.g]

13. Operation of the following pumps, which require bearing water for operation, is prohibited in a waste tank containing saltcake **[TSR SAC 5.8.2.43.ee]**:
    - Slurry pump
    - Telescoping transfer pump when operated for the purpose of waste tank recirculation

    This prohibited operation does not apply to waste tanks that contain a limited amount of saltcake, such that the resulting hydrogen release (assuming instant release of all trapped gas contained in the saltcake) would not exceed the Gas Release Criteria.

14. Operating procedures shall address the requirement to have second person verification of the controlled parameters identified in Section 4.3.2.3. These may include (depending on the activity and controlled parameters) the following:
    1. Waste tank mixing device or transfer pump speed setting
    2. Waste tank mixing device turntable operation (rotating or indexed)
    3. Mixing eductor turntable operation (rotating or indexed)
    4. Saltcake dissolution liquid addition rate or saltcake interstitial liquid removal rate (if pump capacity exceeds the allowable addition/removal rate)
    5. Transfer pump/waste tank recirculation flow rate (if pump capacity exceeds the allowable recirculation rate)

15. Saltcake interstitial liquid removal activities using a transfer jet that could exceed the Gas Release Criteria are prohibited. [TSR SAC 5.8.2.43.hh]
This prohibited operation does not apply to unintended transition between free supernate removal and saltcake interstitial liquid removal using a transfer jet. The controls associated with free supernate removal provide adequate protection for trapped gas release for this unintended transition.

16. Saltcake mounds located within a 20 ft radius from the center of the evaporator concentrate receipt riser in Tank 30, Tank 37, and Tank 38 are excluded from consideration as part of the bulk saltcake layer. Therefore, transfers out of an evaporator drop tank that exposes these saltcake mounds are not considered interstitial liquid removal.

17. If the facility recognizes the occurrence of an unintended saltcake interstitial liquid removal activity during a free supernate removal activity, then immediately shut down the transfer and contact engineering.

18. Actual/projected waste level may be used to credit the vapor space volume when calculating trapped gas release during saltcake interstitial liquid removal. Based on the actual/projected waste level assumed as the initial level in the GRM evaluation for interstitial liquid removal, operating procedures shall appropriately address the requirement to perform an adequate number of vapor space turnovers and/or verifying vapor space hydrogen concentration (see Section 4.3.2.4.2 for requirement of second person verification). For example,

If the assumed initial level is the tank level prior to free supernate removal activity, verification of vapor space hydrogen concentration shall be performed prior to initiation of free supernate removal activity.

If the assumed initial level is a projected level between the current tank level and the bulk saltcake with some margin to account for uneven saltcake layer or a layer of supernate on top of the saltcake, then verification of vapor space hydrogen concentration shall be performed prior to initiation of free supernate removal activity and also between the projected level and the bulk saltcake layer.

4.4 TANK FILL LIMITS PROGRAM

This section is not applicable to tanks in Acidic Chemical Cleaning Mode or Closure Mode. As a Best Management Practice, the fill level for tanks in Acidic Chemical Cleaning Mode will be documented in the ERD as described in Section 6.3. Waste tanks in Closure Mode are intentionally being filled with grout and are not protected by a fill limit. Waste tank overflow is considered not possible for a Closure waste tank and the flammability is not protected by a fill limit, but by the methods described in Section 4.6.

Tank fill limits are imposed for each waste tank. The tank fill limit will incorporate the lowest fill limit imposed by all programs of the DSA and CSTFs SCDHEC Construction Permit [Ref. 40].

The DSA credits a maximum waste storage tank level for the most restrictive of the following considerations:

- Maximum Fill Limit (maximum tank level that protects initial conditions/assumptions used in the accident analysis)
- Overflow Limits (these limits also protect assumptions associated with tank wall exposed area)
- Structural Integrity Fill Limit
- Siphon Limits for Waste Tanks 1-4 and 7-11
- Flammable Transient Limits Due to Trapped Gas Release
- Flammability Level (used for time to LFL [CLFL for Tank 50] calculations)
- Maximum annulus equilibrium liquid level (following a tank wall breach) for waste tanks in Non-Acidic Chemical Cleaning Mode

Additionally (outside of DSA requirements), the following should be considered once waste removal begins on a waste tank.

- Lowest Leak Site (SCDHEC Construction Permit Requirement)

The tank fill limit shall account for the maximum amount of waste (i.e., 15,000 gallons) associated with a Transfer Error event (excluding waste tanks in Non-Acidic Chemical Cleaning Mode), and associated instrument uncertainties, unless the SCDHEC Construction Permit criterion remains bounding (i.e., results in the lowest setpoint value). The SCDHEC Construction Permit does not require consideration of the maximum amount of waste associated with a Transfer Error event (i.e., 15,000 gallons).

The following fill limits do not include maximum missing waste or instrument uncertainty. When comparing an HLLCP setpoint to these limits, maximum missing waste and instrument uncertainty should be accounted for unless otherwise noted below.

MAXIMUM FILL LIMIT BASED ON TANK TYPE TO PROTECT INITIAL CONDITIONS/ASSUMPTIONS IN ACCIDENT ANALYSES

This is the maximum tank level that protects initial conditions/assumptions used in the Aerosolization, Waste Tank Annulus Explosion, Waste Tank/Pump Tank Overheating, and Waste Tank Wall Failure events [Ref. 1].

The maximum fill limits for each waste tank type are listed in Table 3.4-2 of the DSA.

Table 4: Waste Tank Type Maximum Fill Limits

Waste Tank Type	Maximum Fill Limit (inches)
Type I	274
Type II	304
Type III/IIIA	372
Type IV	386

MAXIMUM FILL LIMIT TO PROTECT WASTE TANK OVERFLOW

This is the level at which the tank would physically overflow (typically through a sidewall penetration) [Ref. 44].

Table 5: Waste Tank Level Limitations for Overflow

Tank	Tank Type	Fill Limit (inches)
1F	I	275.9
2F	I	279.2
3F	I	280.0
4F	I	280.3
5F	I	Closed
6F	I	Closed
7F	I	278.2
8F	I	279.5
9H	I	277.2
10H	I	276.4

11H	I	280.0
12H	I	Closed
13H-15H	II	316.2
16H	II	Closed
17F-20F	IV	Closed
21H-24H	IV	382.7
25F	IIIA	374.2
26F	IIIA	375.5
27F	IIIA	373.5
28F	IIIA	373.6
29H-32H, 33F, 34F	III	378.6
35H-37H	IIIA	378.0
38H	IIIA	375.4
39H	IIIA	373.9
40H	IIIA	374.5
41H	IIIA	373.8
42H	IIIA	374.4
43H	IIIA	373.6
44F, 45F	IIIA	373.9
46F	IIIA	373.8
47F	IIIA	373.5
48H	IIIA	375.5
49H	IIIA	374.3
50H	IIIA	375.5
51H	IIIA	375.0

MAXIMUM FILL LIMIT TO PROTECT MAXIMUM WALL STRESS (TYPE I AND II TANKS)

This is the level at which the tank wall stresses would exceed a maximum allowed value (limiting for only Type I and II tanks) [Ref. 19]. This level is dependent on the specific gravity (SpG) of the waste contents. The SpG may be determined by calculating a composite SpG for the tank under evaluation, reflective of the tank conditions regarding sludge, salt, and supernate volumes and associated SpG in each represented phase.

Table 6: Type I Waste Tank Level Limitations for Wall Stress

Specific Gravity (SpG)	Fill Levels			
	Unflawed Tanks with or without SMP/CSMP (inches)	Flawed Tanks without SMP/CSMP (inches)	Flawed Tanks with Operating SMP (inches)	Flawed Tanks with Operating CSMP (inches)
	[Ref. 19, Table E-1]	**[Ref. 19, Table E-5]**		
1.00	276.0	276.0	276.0	276.0

1.20	276.0	276.0	276.0	276.0
1.40	276.0	276.0	276.0	276.0
1.50	276.0	276.0	260.0	276.0
1.60	274.0	266.0	236.9	256.9
1.80	244.0	237.0	211.2	228.9
2.00	222.0	213.4	190.1	206.1
2.20	203.0	198.5	177.4	191.9

Table 7: Type II Waste Tank Level Limitations for Wall Stress
[Ref. 19, Table E-6]

Specific Gravity	Fill Level		
	Flawed Tanks without SMP/CSMP (inches)	Flawed Tanks with Operating SMP (inches)	Flawed Tanks with Operating CSMP (inches)
1.00	306.0	306.0	306.0
1.20	306.0	306.0	306.0
1.40	302.0	290.4	302.0
1.60	302.0	262.1	284.9
1.80	268.0	232.5	252.8
2.00	242.0	210.0	228.4
2.20	232.0	203.0	219.6

MAXIMUM FILL LIMIT TO PREVENT SIPHON THROUGH COOLING COILS (TANKS 1-4 AND 7-11)

This is the level above which it would be physically possible to siphon waste from the tank through the cooling coils (for Waste Tanks 1-4 and 7-11). Based on the maximum tank liquid level with respect to the Chromate Cooling Water System valve house header high point, the maximum fill limit to prevent siphon through cooling coils for Waste Tanks 1-4 and 7-11, determined in Reference 51, is presented in the table below.

Table 8: Type I Waste Tank Level Limitations for Siphon through Cooling Coils

Tank	Fill Limit (inches)
1F	245
2F	246
3F	243

4F	243
7F	246
8F	242
9H	249
10H	244
11H	252

MAXIMUM FILL LIMIT BASED ON FLAMMABLE TRANSIENT ASSUMPTIONS

This is the level required to protect a plume of hydrogen gas released into the waste tank vapor space as a result of trapped gas release activities in the waste tank from exceeding the LFL.

For waste tanks that do not have an operating waste tank mixing device or waste tanks that contain only slurried sludge (for the solids present in the tank) and the specific waste tank mixing device (planned for operation) has been operated less than or equal to 180 days ago, the waste tank maximum fill limits in Table 4 protect the vapor space volume to ensure flammable transients do not pose a safety concern.

For waste tanks that contain only slurried sludge and have an operating waste tank mixing device and the specific waste tank mixing device (planned for operation) has not been operated within 180 days, the waste tank level limitations for protection of flammable transients is performed by the Gas Release Program (see Section 4.3) and is not part of the criteria for HLLCP setpoint determination [Ref. 1].

For waste tanks that contain saltcake, settled sludge, or any combination of saltcake, settled sludge, or slurried sludge and have an operating waste tank mixing device (planned for operation), the waste tank level limitations for protection of flammable transients is performed by the Gas Release Program (see Section 4.3) and is not part of the criteria for HLLCP setpoint determination [Ref. 1].

MAXIMUM FILL LIMIT TO PROTECT WASTE TANK FLAMMABILITY LEVEL

This is the level to protect the time to LFL for a waste tank (excluding Type I/II waste tanks in Acidic Chemical Cleaning Mode and waste tanks in Closure Mode), which in turn protects the waste tank flammability classification, upon loss of ventilation. The time to LFL for a waste tank is determined as the lower of the radiolytic time to LFL or the spontaneous time to LFL. The waste tank vapor space used in the radiolytic time to LFL calculation is protected by the HLLCP setpoint; whereas, the one used in the spontaneous time to LFL calculation is based on the actual/projected tank level. Both the HLLCP setpoint and actual/projected tank level shall be adjusted to account for missing waste volume associated with a Transfer Error event (see Section 4.1.2). Therefore, the maximum fill limit to protect the waste tank flammability level is the lower of the HLLCP setpoint or the maximum tank level protecting the waste tank flammability classification.

MAXIMUM ANNULUS EQUILIBRIUM LIQUID LEVEL

This is the level to protect maximum annulus equilibrium liquid level (following a tank wall breach) for Type I/II waste tanks in Non-Acidic Chemical Cleaning Mode. The tank fill limits of less than or equal to 63.8 inches [Type I] and 64.8 inches [Type II] provide controls to protect a maximum annulus equilibrium liquid level following a tank wall breach [Ref. 1]. These fill limits are not required to account for maximum missing waste [Ref. 1].

LOWEST LEAK SITE

In addition, the SCDHEC Construction Permit requires that once waste removal begins on a tank with a leak or crack and the waste is removed to a level below the lowest known leak or crack, that level shall become the maximum operating level of the tank and shall not be exceeded unless the exceedance is a temporary result of the waste removal process [Ref. 40]. The locations of known leaksites are documented in Reference 42.

4.4.1 IMPLEMENTATION ACTIONS

1. The most limiting of the maximum fill levels for each individual waste tank shall be determined in WCS [Ref. 11].

2. The WCS shall verify that the HLLCP set point protects the most limiting of the maximum fill levels [accounting for Maximum Missing Waste (except waste tanks in Non-Acidic Chemical Cleaning Mode) and instrument uncertainty] for each individual waste tank.

3. Current HLLCP set points shall be documented in the ERD [Ref. 2].

4. Proposed HLLCP set points that support planned operations (e.g., waste tank to waste tank transfers) shall be compared against the waste tank fill limits and documented by an engineering evaluation or by WCS [Ref. 11].

5. The ERD [Ref. 2] shall be updated with the new HLLCP set point after the field work to set the HLLCP at the proposed set point is complete and prior to the planned activity.

6. Tank Farm influents shall be updated in WCS [Ref. 11] to ensure that the HLLCP is adjusted at the appropriate height in the tank to maintain greater than 7 days to LFL and tank classification.

7. Waste tank to waste tank transfers shall be pre-evaluated to protect fill limits.

8. The Waste Tank Structural Integrity Cognizant Engineering function shall maintain a reference document(s) of current overflow limits (all waste tanks), structural integrity limits (all waste tanks), and lowest known leak sites (all waste tanks).

9. The WCS owner shall be notified upon discovery of a new leaksite and current HLLCP setpoints shall be compared to the leaksite location and adjusted if necessary.

4.5 WASTE TANKS IN ACIDIC CHEMICAL CLEANING MODE

The Chemical Cleaning process involves two distinct modes: Acidic Chemical Cleaning and Non-Acidic Chemical Cleaning. Non-Acidic Chemical Cleaning Mode will typically be entered following completion of Acidic Chemical Cleaning in the waste tank. However, a tank may possibly transition between the two modes several times during a chemical cleaning campaign in some circumstances. The treatment tank will enter Acidic Chemical Cleaning Mode prior to the transfer of oxalic acid into the tank; acid may be added at up to a 20:1 volume ratio at a maximum concentration of 8 wt.% oxalic acid to sludge. The tank may enter Non-Acidic Chemical Cleaning Mode once the entry requirements are met. Routine flammability controls apply to tanks in Non-Acidic Chemical Cleaning Mode.

Only Type I and Type II waste tanks (except Tank 1) are allowed to enter Acidic Chemical Cleaning Mode. The tanks in Acidic Chemical Cleaning Mode will be required to have a minimum purge ventilation flow rate with flow indication [Refs. 1, 34]. These flow rates maintain the hydrogen concentration in the waste tank below 25% of the LFL, and ensure at least 3 days to LFL in the event that ventilation is lost. The time to LFL in the annulus due to a leak during Acidic Chemical Cleaning is 3.25 days [Ref. 26]. Because of the minimum purge flow requirement, additional vapor space turnovers are not required. In addition, the maximum heights are specified for the HLLCPs in tanks in Acidic Chemical Cleaning Mode [Ref. 34].

Spray washing may be conducted in Acidic Chemical Cleaning Mode as part of the waste tank chemical cleaning evolution. Liquid additions shall be limited to those from batch sources less than or equal to 8,000 gallons total volume that do not have a continuous makeup capability. The liquid source system shall be considered to have continuous makeup capability if the system has an automatic or manual fill provision that is not electrically or mechanically isolated. The electrical or mechanical isolation shall contain two independent means of isolation (e.g., two isolation valves; one isolation valve and open disconnect for liquid source transfer pump) [Ref. 1]. Spray washing does not contribute additional hydrogen beyond that generated during batch additions of oxalic acid [Ref. 1].

4.5.1 IMPLEMENTATION ACTIONS

The following requirements shall be met prior to placing a waste tank in Acidic Chemical Cleaning Mode:

1. The tank shall be classified as a Chemical Cleaning Tank in the ERD [Ref. 2]
2. If the projected numbers of tanks capable of becoming flammable following a seismic event (including the effects of post seismic trapped gas release and number of waste tanks in Chemical Cleaning Mode) within 7 days are not within the restrictions of the TSR, then the evaluated activity shall not be performed. [TSR AC 5.8.2.27.a]
3. A path forward shall be provided to DOE (addressing the additional risk and recovery time) if a transfer required to mitigate a waste tank leak causes additional waste tanks (more than 14) to have the potential to become flammable in less than seven days. Because the transfer is mitigating a degraded condition (i.e., placing the facility in a safer condition), the path forward is not required to be provided to DOE prior to initiating the transfer. [TSR AC 5.8.2.27.c]

4. The emergency response priority classification shall be determined by the time to LFL. Response priorities shall be, in order of decreasing priority: Priority 1 Tanks (seismic time to LFL < 24 hours), Priority 2 Acidic Chemical Cleaning Tanks (tank primary, then annulus), then remaining Priority 2 Tanks (seismic time to LFL < 7 days).
5. Bulk saltcake dissolution and removal of interstitial liquid from saltcake are prohibited.

4.6 CLOSURE MODE

A requirement for tanks in the Closure Mode (only applies to Type I, II, and IV waste tanks) is that the radiolytic hydrogen generation rate shall be less than or equal to 0.5 ft^3/hr evaluated at 25ºC with a NO_{eff} equal to zero [Ref. 1]. Using the Radiolytic Hydrogen Generation Model outlined in Section 4.1.2.2.1, the radiolytic hydrogen generation rate can be calculated.

An evaluation was performed on the flammability of Type I, II and IV waste storage tanks during grouting operations [Ref. 36]. The evaluation used a maximum vapor space temperature of 100ºC. The maximum vapor space temperature in an inactive dry tank is 75ºC so using a higher vapor space temperature provides conservatism in the results. A radiolytic hydrogen generation rate of 0.63 ft^3/hr was determined to be the maximum rate at which a Type I, II, or IV waste storage tank can remain at or above 10 days time to LFL at the primary waste tank historical maximum waste level with a vapor space temperature of 100ºC. This corresponds to a radiolytic hydrogen generation rate of 0.5 ft^3/hr evaluated at 25ºC which is consistent with the temperature used to evaluate the LFL of hydrogen (See Section 4.1.2.2).

During waste tank grouting, the organic content of the components that will comprise the grout will contribute insignificant quantities to the flammable vapor space concentration. As such, the contribution from trace organics (5% LFL for hydrogen) assumed in waste tanks undergoing grouting will bound any volatile releases from the grout [Ref. 37].

Once the flammability-related Closure Mode entry prerequisites have been met for a waste storage tank, the HLLCP is not required for flammability controls in a tank that has been declared a Closure Waste Tank [Ref. 1].

Even though Closure Mode contains no other DSA requirements for flammable vapors, compliance with codes and standards (i.e., NFPA Standard 69 [Ref. 13]) continues to apply until grouting is complete. As such, flammable vapor control will be maintained by: a) operating forced ventilation, or b) sampling the vapor space to determine flammable vapor concentrations, or c) a combination of a and b. A methodology for compliance is contained in the FTF and HTF Fire Hazard Analyses [Refs. 38, 39] and is defined in the following paragraphs along with the implementation items of Section 4.6.1.

From S-CLC-H-01248, a waste tank with a radiolytic hydrogen generate rate meeting the Closure Mode pre-requisite cannot reach an equilibrium condition of 100% of the LFL_{OC} so long as the tank level is less than 60 inches for a Type I tank, less than 140 inches for a Type II tank or less than 230 inches for a Type IV tank. Until grout is added to the tank, reducing the available vapor space volume, a Closure Mode tank will contain a small waste volume which will yield a much lower tank level than the values above. Since, by definition, a Very Slow Generation waste tank must also not reach equilibrium at 100% of the LFL_{OC}, it is reasonable to use the

methodology described in Section 6.2 for Closure Mode waste tanks until grout fill is initiated.

While adding grout to the primary tank and annulus, it is expected that forced ventilation will be operated in order to provide radiological contamination control for the displaced vapor space. This will simultaneously provide flammable vapor control. When grout addition is not actively in progress, the ventilation system can continue to be operated or periodic flammable vapor sampling can be performed.

Once the primary tank (or annulus) is filled to the base of the risers, an alternate strategy is required. At this point in the process, each riser (primary or annulus) can be considered a stand-alone location for flammable vapor accumulation. However, the hydrogen being generated by the waste will have to diffuse through 20+ vertical feet of grout to reach the riser openings. It is reasonably conservative to assume that the diffused hydrogen will be distributed equally among the available risers, i.e., the flammable vapor concentration in any one riser will be comparable to all risers of that location (primary or annulus). Based on this approach, at least one unfilled riser for each applicable location (primary and/or annulus) shall be sampled periodically to monitor for flammable vapor concentrations. Additionally, any riser that is about to be grouted shall also be monitored prior to grout pouring; the riser sampled for grouting can be used to satisfy the requirement for that location/period. Measured flammable vapor concentrations < 10% LFL require no action. If the measured value is >10% LFL but less than 20% LFL, prior to grouting a monitoring frequency must be established to ensure that the riser vapor space does not exceed 20% without recognition of the hazard. If the measured value is ≥20% LFL but less than 55% LFL, compensatory measures determined by an engineering evaluation shall be carried out to reduce the flammable vapor concentration prior to grouting [Ref. 39]. If ventilation is utilized as the compensatory measure, successful removal shall be confirmed via follow-up sampling. Risers with a measured flammable vapor concentration ≥ 55% LFL shall be ventilated to remove flammable vapors. Successful removal shall be confirmed via follow-up sampling prior to further activity. If any riser is found to be ≥55% LFL, other unfilled risers for that location (primary or annulus) shall be sampled and action taken based on the values above.

During riser grout pouring, continuous vapor space monitoring is not required; however if grout pouring is interrupted prior to filling the riser, vapor space monitoring is required if the duration of the interruption is greater than 8 hours. If the riser is found to be greater than or equal to 20% LFL, action should be taken based on the values above.

4.6.1 IMPLEMENTATION ACTIONS

1. Prior to placing a waste storage tank in Closure Mode, an engineering evaluation shall be performed to ensure the flammability-related Mode entry prerequisites for Closure Mode are met. For hydrogen generation rate requirement, an analytical uncertainty of 2 Sigma shall be included when comparing against the hydrogen generation rate limit.

2. The flammability status of the waste tank shall be classified as Closure in the ERD. Conductivity Probe Height/Fill Limit, Hydrogen Analyzer Limit and Number of Required Turnovers are not applicable to a tank in Closure Mode.

3. From the time when a waste tank is declared in Closure Mode until grout pouring is initiated, the waste tank shall be treated as a Very Slow Generation waste tank and shall be ventilated/monitored as described in Section 4.1.3.

4. Prior to initiating grouting operations, perform an engineering evaluation to determine the following (not applicable to riser grouting):

   a. minimum purge flow required to maintain a flammable vapor concentration below 20% LFL during grouting

   b. required time for response to a loss of ventilation (e.g. restoration of ventilation or periodic flammable vapor sampling)

5. Prior to initiating grouting, monitor the vapor space to ensure that the flammable vapor concentration is less than 20% LFL. If the result is greater than or equal to 20% LFL, operate forced ventilation until the flammable vapor concentration is less than 20% LFL (not applicable to riser grouting).

6. When grouting of a Closure Waste Tank is initiated, the following shall be performed for the primary tank and its annulus until each of these locations is completely filled to ensure that flammable vapor concentration remains below 20% LFL:

   a. Ventilate the location with forced ventilation

   OR

   b. Perform periodic flammable vapor sampling

   If ventilation is being used to satisfy this attribute and ventilation flow is lost, initiate periodic flammable vapor sampling until forced ventilation is restored (not applicable to riser grouting).

7. Upon completion of bulk (non-riser) grouting perform the following for unfilled risers:

   a. Sample one primary and one annulus riser for flammable vapor concentration weekly. If riser grouting is to be performed, the riser to be grouted may count as one of the risers sampled (annulus or primary)

   - If measured vapor concentration is less than 20% of the LFL, no action is required.

- If vapor concentration is greater than or equal to 20% of the LFL, a compensatory measure, as defined in an engineering evaluation, shall be performed to bring the concentration below 20%.

  - Additionally, other unfilled risers in that location (primary or annulus) shall be sampled to determine flammable vapor concentration. Compensatory measures shall be performed for each riser found with a concentration greater than or equal to 20% LFL.

b. If data shows the flammable vapor concentration remains below 10% LFL, the frequency of sampling may be decreased based on an engineering evaluation.

8. For riser grouting, perform the following:

a. Prior to grouting of a riser, sample the flammable vapor concentration.

- If the grouting concentration is less than 10% LFL grouting can proceed with daily monitoring.

- If the concentration is between 10% and 20% LFL, a monitoring frequency must be established to ensure that the riser vapor space does not exceed 20% without recognition of the hazard. Grouting may proceed with established monitoring frequency.

- If the concentration is greater than or equal to 20% LFL but less than 55%, perform an engineering evaluation to determine compensatory actions to reduce flammable vapor concentration.

- If the measured flammable vapor concentration is greater than or equal to 55% LFL, perform the following:

  - Ventilate riser with forced ventilation. Perform a follow-up sample of that riser after ventilating to ensure LFL <20%.

  - Sample all other unfilled risers for that location (primary or annulus) and perform required actions defined above for any riser with a measured concentration ≥20% LFL

b. If grouting is interrupted prior to filling the riser perform the following actions:

- If interruption duration is less than 8 hours, no action is required and grouting may proceed.

- If interruption duration is greater than 8 hours, monitoring of vapor space concentration shall be completed and actions performed as stated in (a) to ensure the flammable vapor concentration is < 20% LFL before grout pouring can continue.

4.7 OIL CONTROL PROGRAM

Programmatic controls through the Oil Control Program shall be established to prevent the introduction (e.g. via air compressors, transfer pumps, waste tank mixing devices) of significant flammable vapors from lubricating or hydraulic oil into analyzed spaces (e.g., evaporator pots, evaporator cells, transfer facilities, waste tanks, and waste tank annuli) [Ref. 1]. Reference 21 lists the currently evaluated compressor lubrication oils that can be used in the facility without causing these analyzed vapor spaces to exceed their 5% CLFL requirement. The oils were evaluated at three temperatures: 1) 160^0C if used in the 2H evaporator, 2) 186^0C if in the 3H evaporator, 3) 100^0C if in the waste tanks, pump tanks, etc. In addition, Reference 47 evaluates a lubrication oil specific for use in CSMPs. In order to prevent unevaluated lubricating or hydraulic oils from being used in the facility, certain implementation actions have been established to control the introduction of new lubricating or hydraulic oils within the facility.

4.7.1 IMPLEMENTATION ACTIONS

1. For installed facility compressors, the model work orders for F and H Tank Farm's preventive maintenance shall ensure the use of approved lube oils.

2. For portable compressors, the preventive maintenance program for these compressors shall ensure that only approved lube oils are used. The facility shall ensure that only those compressors serviced under an appropriate PM program are used in the facility.

3. The lubricating or hydraulic oils from the equipment that can enter the vapor spaces of the Tank Farm equipment shall be evaluated to ensure an oil is selected that does not cause the analyzed vapor spaces to exceed the 5% LFL requirement mentioned above.

4.8 INTERIM SAFETY BASIS REQUIREMENTS

Potential Inadequacy Recognition of the Effect of Organics on Hydrogen Generation Rates in the CSTF (PISA PI-2017-0003) was declared on February 28, 2017 and the following compensatory measures listed in the Evaluation of the Safety of the Situation (ESS), U-ESS-G-00007, that impact this PDD. These compensatory measures supersede the requirements of this PDD for the affected sections [Ref. 57].

Compensatory Measure 2.2.1 - Prior to the addition of an organic compound to CSTF waste, the addition will be evaluated by engineering to confirm that either:

A. The organic compound has previously been added to CSTF waste in quantities greater than or equal to the proposed addition.

OR

B. The organic addition will not impact the conclusions of this ESS or the CSTF Organic Hydrogen Generation Report [Ref. 58].

Compensatory Measure 2.2.6 - Tank 50 will be maintained as a Very Slow Generation Tank.

Compensatory Measure 2.2.8 – For Type I, II, III, and IIIA waste storage tanks:
If the waste tank supernate temperature limit established in the CSTF Emergency Response Data document [Ref. 2] is greater than 60°C, then the affected tank will be classified as a Rapid Generation Tank and will be subject to the corresponding DSA, TSR, and ESS controls.

Compensatory Measure 2.2.9 – For Type IV waste storage tanks:
If the waste tank supernate temperature limit established in the CSTF Emergency Response Data document [Ref. 2] is greater than 65°C, then the affected tank will be classified as a Rapid Generation Tank and will be subject to the corresponding DSA, TSR, and ESS controls.

Compensatory Measure 2.2.18 – For waste tanks under Waste Tank Quiescent Time Program with non-infinite quiescent times:
Prior to establishing a waste tank supernate temperature limit or sludge/salt temperature limit greater than 60°C in the CSTF Emergency Response Data document [Ref. 2], quiescent time calculations for the affected tank will meet the requirements established in Attachment 4 of Reference 57.

4.8.1 IMPLEMENTATION ACTIONS

1. Organic additions to CSTF waste shall be pre-evaluated by engineering to confirm that the quantity of the proposed additions is less than or equal to the evaluated quantity. Acceptability of this evaluation will be documented in the Technical Review of the associated work document (e.g., procedure, work package) [U-ESS-G-00007, 2.2.1.a].

2. If the quantity of the proposed organic additions is greater than the evaluated quantity or if the organic compound has not been evaluated, a new organic chemical evaluation will be required having an increased scope to ensure that the additions will not impact the conclusions of the ESS or the CSTF Organic Hydrogen Generation Report [Refs. 57, 58] [U-ESS-G-00007, 2.2.1.b].

3. Tank 50 will be maintained as a Very Slow Generation Tank in the ERD [U-ESS-G-00007, 2.2.6].

4. For Type I, II, III, and IIIA waste tanks with Slow/Very Slow classification, the supernate temperature limit (excluding dry salt tanks) shall be less than or equal to 60°C. This limit will be tracked in the ERD [U-ESS-G-00007, 2.2.8].

5. If the supernate temperature limit for a Type I, II, III, or IIIA waste tank (excluding dry salt tanks) classified as Slow/Very Slow Generation Tank is greater than 60°C, then the affected waste tank shall be classified as a Rapid Generation Tank [U-ESS-G-00007, 2.2.8].

6. For Type IV waste tanks with Slow/Very Slow classification, the supernate temperature limit (excluding dry salt tanks) shall be less than or equal to 65°C. This limit will be tracked in the ERD [U-ESS-G-00007, 2.2.9].

7. If the supernate temperature limit for a Type IV waste tank (excluding dry salt tanks) classified as Slow/Very Slow Generation Tank is greater than 65°C, then the affected waste tank shall be classified as a Rapid Generation Tank [U-ESS-G-00007, 2.2.9].

8. Operating procedures (e.g., roundsheets) shall include the notification to engineering if the waste tank supernate temperature reaches 55°C for Type I, II, III, or IIIA waste tanks or 60°C for Type IV waste tanks that are classified as Slow/Very Slow Generation Tanks for consideration of changing the waste tank classification to Rapid Generation Tank [U-ESS-G-00007, 2.2.8 & 2.2.9].

9. For waste tanks under the Quiescent Time Program with non-infinite DSA defined Quiescent Times (i.e., Seismic Quiescent Time and/or Spontaneous Quiescent Time), prior to establishing a waste tank supernate temperature limit or sludge/salt temperature limit greater than 60°C in the ERD, an engineering evaluation shall be performed to establish new hydrogen generation rates [U-ESS-G-00007, 2.2.18]. The evaluation shall incorporate experimental evidence from real waste testing of representative waste samples under conditions that bound those that are anticipated for the affected waste tank. These conditions include (but are not limited to) [Ref. 57]:

   a. Temperature of the waste.
   b. Aluminum concentration in the waste.
   c. Total organic carbon (TOC) concentration in the waste.

   The conservative direction for all conditions listed is maximum.

   The evaluation shall incorporate experimental evidence to calculate new hydrogen generation rates as follows [Ref. 57]:

   Eq. #94 $$x_{RAD,\ ESS} = x_{EXP} + \left[\frac{R_{\beta/\gamma} H_{\beta/\gamma}}{10^6}\right]$$

   Eq. #95 $$x_{H2,\ ESS} = x_{RAD,\ ESS} + x_{CORR}$$

   Eq. #96 $$Q_{H2,\ ESS} = x_{H2,ESS} \frac{(T+273)}{(T_i+273)}$$

   Where:

   $x_{RAD,\ ESS}$ = New radiolytic† hydrogen generation rate (HGR) at 25°C, ft^3/hr
   x_{EXP} = Bounding experimental HGR at 25°C basis, ft^3/hr
   $R_{\beta/\gamma}$ = Volume (ft^3) of hydrogen generated per MBTU of heat added from beta or gamma decay (for calculation, see Equation 8 in Section 4.1.2.2.1)
   $H_{\beta/\gamma}$ = Heat generated by beta and gamma decay, BTU/hr (for calculation, see Equation 10 in Section 4.1.2.2.1)
   $x_{H2,\ ESS}$ = New total HGR at 25°C, ft^3/hr

† The newly derived radiolytic HGR ($x_{RAD,\ ESS}$) includes an empirical HGR term (x_{EXP}). This empirical term may comprise hydrogen generated via non-radiolytic mechanisms (e.g., thermolysis). However, to maintain congruence with the methodology described in other sections, the new HGR is still termed "radiolytic."

x_{CORR} = Corrosion induced hydrogen generation rate at 25°C, ft^3/hr. This HGR has been shown to be insignificant except during Acidic Chemical Cleaning which is prohibited under Compensatory Measure 2.2.2 of Reference 57.

$Q_{H2, ESS}$ = New temperature corrected HGR, ft^3/hr

T = Temperature at which $Q_{H2, ESS}$ is to be evaluated, ^oC

T_i = Initial temperature at standard pressure of 1 atm (e.g., 25^oC)

The newly derived temperature corrected HGR ($Q_{H2, ESS}$) shall be used in place of all instances of the original temperature corrected HGR (Q_{H2}) for calculations in Sections 4.2 and 4.3 (e.g., GRM Quiescent Time, Seismic Quiescent Time, Spontaneous Quiescent Time, NFPA Spontaneous Quiescent Time).

10. For waste tanks under the Quiescent Time Program with non-infinite DSA defined quiescent times, prior to establishing a waste tank supernate temperature limit or sludge/salt temperature limit greater than 60^oC in the ERD, an engineering evaluation shall be performed to verify the contributions of organic compounds to flammability [U-ESS-G-00007, 2.2.18]. The evaluation shall incorporate experimental evidence from real waste testing of representative waste samples. Evaluated experimental data shall include [Ref. 57]:

    a. Comprehensive volatile organic analysis (VOA) and semi-volatile organic analysis (SVOA) of the representative waste samples. If specific volatile organics are not analyzed, n-butanol may be considered as a representative organic for the VOA because it is the primary volatile organic product of the thermal degradation of most of the organic compounds seen in the Tank Farm waste. If specific semi-volatile organics are not analyzed, diisopropylnaphthalenes may be used as a representative organic for the SVOA due to the fact that the organic compound has a high Henry's Law constant and a relative low LFL.
    b. Vapor space methane sampling conducted under conditions that bound those that are anticipated for the affected waste tank (e.g., temperature, aluminum concentration, TOC concentration).

    The engineering evaluation shall show that the combined flammability contributions from organics in items a and b are less than or equal to a total 5% organic contribution to the hydrogen LFL at 100^oC according to Equation 97.

    Eq. #97 $$\%LFL = \sum_N \frac{[N]}{LFL_N} * 100\%$$

    Where:

    %LFL = Total organic contribution to the hydrogen LFL, % by volume

    [N] = Vapor space concentration of flammable organic compound N, vol. frac.

    LFL_N = LFL for flammable organic compound N at 100^oC, vol. frac.

11. Liquid additions [excluding small quantity of water additions (e.g., bearing water in-leakage, reel tape flushing) or chemical additions (e.g., caustic/nitrite solutions to comply with the Corrosion Control Program)] to the waste tank from which the representative

waste samples have been collected will invalidate the results of the real waste testing that supports Implementation Actions 9 and 10.

12. Waste tanks affected by U-ESS-G-00007 Compensatory Measure 2.2.18 may exit the compensatory measure via the following sequence [Ref. 57]:

    a. Verify that waste tank temperatures (i.e., supernate and sludge/salt) are less than or equal to 60°C.
    b. Complete mixing device operations in accordance with calculated quiescent times that meet the requirements established in Implementation Action 9 listed above. Waste tank mixing device operations shall meet the requirements of Section 4.2.1.1 for a 100% hydrogen depletion operation.
    c. Issue a new ERD document revision that: (1) establishes a waste tank supernate temperature limit and a sludge/salt temperature limit less than or equal to 60°C and (2) establishes quiescent times calculated using the methodology described in Section 4.2.

13. Waste tanks that have infinite DSA defined quiescent times but non-infinite non-DSA defined quiescent times (i.e., GRM Quiescent Time, NFPA Spontaneous Quiescent Time) must maintain the supernate temperature limits and sludge/salt temperature limits less than or equal to 60°C.

14. Waste tanks that undergo bulk saltcake dissolution and interstitial liquid removal activities must maintain the supernate temperature limits less than or equal to 50ºC (to comply with Corrosion Control Program [Ref. 8]) and the sludge/salt temperature limits less than or equal to 60ºC.

15. Waste tanks that are currently not under the Quiescent Time Program and undergo sludge agitation must maintain the supernate temperature limits and sludge/salt temperature limits less than or equal to 60ºC.

5.0 OUTPUT DOCUMENTATION

The output documents generated in compliance with this PDD shall ensure independent verification or validation of results and conclusions. Output documents include, but are not limited to, calculations, procedures and technical reports.

Calculations issued as output documents shall be confirmed calculations in accordance with the requirements of the E7 Manual, Procedure 2.31A. Technical Reports issued as output documents shall comply with the requirements of E7 Manual, Procedure 3.60. Assumptions and recommendations from these reports shall be addressed in the Design Authority Technical Review written against the Proposed Activity. Additionally, the output documents will be included in the USQ review process against the Proposed Activity per Manual 11Q, Procedure 1.05.

6.0 BEST MANAGEMENT PRACTICE

6.1 GAS RELEASE MODE

Best management practice will be to limit releases such that the vapor space remains below the TSR hydrogen concentration LFL limit (i.e., as documented in the ERD), which accounts for potential organics and instrument uncertainty according to the designated SAV, by controlling number of waste tank mixing devices, mixing device speed/indexing, transfer pump/recirculation pump flow rate, etc. The best management practice, which includes the use of calculations, is to ensure that the TSR hydrogen concentration interlocks (second level of control) are not activated. The TSR hydrogen concentration LFL limit will be designated in the ERD. Once the ERD is approved, this will drive the revision of the Instrument Scaling and Setpoint Document, which will allow implementation of the required indicated hydrogen concentration reading in the facility. References 3, 4, and 31 provide instrument uncertainty values for a range of various SAVs, which are employed to determine the TSR hydrogen concentration LFL limit (i.e., indicated hydrogen reading).

The methodology described in Sections 4.3.2.3 must be followed during all gas release activities in sludge and salt.

6.2 TIME TO LFL METHODOLOGY

The primary flammable vapor contribution to the radiolytic time to LFL is the release of hydrogen gas generated from waste due to water decomposition. The hydrogen generation rate equations used in the time to LFL calculations are functions of both radiolytic heat load, and concentration of nitrate and nitrite anions. There is analytical uncertainty on chemical and radiological composition measurements as reported from laboratories [Ref. 25]. The potential effect of these uncertainties is that the calculated time to LFL could change by about 30%. In addition to the conservatisms already contained within the assumptions of DSA, the tank classification and time to LFL are periodically reviewed against the following criteria to mitigate the potential for tank classification change due to these analytical uncertainties [Ref. 27]:

RAPID GENERATION TANKS with less than 10 days time to LFL

SLOW GENERATION TANKS with less than 36 days time to LFL

VERY SLOW GENERATION TANK with an equilibrium hydrogen concentration greater than 65% LFL_{OC} (70% LFL_{OC} or 85% CLFL for Tank 50)‡.

If any waste tank with the time to LFL is found to meet the above criteria during periodic reviews (e.g., Rapid Generation Tanks with less than 10 days time to LFL, Slow Generation Tanks with less than 36 days time to LFL) [Ref. 27], additional actions are recommended (these actions are not requirements) in order to mitigate this vulnerability of a tank classification change (e.g., chemical additions, lowering HLLCP height, removing waste, etc.).

Additional conservatism is available in the hydrogen generation rate based on a comparison of

‡ It is calculated based on a reduction of 30% uncertainty from 43.8 %CLFL for hydrogen plus 56.2 % CLFL for Isopar® L/organics (~ 0.70 * 43.8 %CLFL + 56.2 %CLFL).

predicted hydrogen generation rate, and measured hydrogen generation rates based on measurements in waste tanks [Ref. 28]. The analysis showed that WCS consistently overpredicts the hydrogen generation rate; especially, in high heat waste tanks (which are the most critical). The observed generation rates measured by gas chromatographs in the non-slurried, high-heat waste tanks (see data in Table 3 of Reference 28) are 4-9 times less than the WCS calculated hydrogen generation rates. This observed conservatism in calculated hydrogen generation rate is due, possibly, to a combination of several factors; including, passive ventilation, radiation leakage from the tanks, radiation absorption by solids, and/or systematic conservatism in heat load or R-value estimates.

The primary flammable vapor contribution to the spontaneous time to LFL is the release of the trapped hydrogen gas from slurried sludge. To determine the amount of trapped hydrogen released from the slurried sludge, the spontaneous time to LFL methodology assumes that the trapped hydrogen release from the slurried sludge is 100% instantaneous release. This is a very conservative assumption because the actual trapped gas release is known to be a time-dependent phenomenon and is not a full release. The data sheets in Reference 56 provide the portable LFL monitor sampling results for Tank 40 from 5/26/15 thru 8/3/15. As can be seen from the data sheets, at no time except during and after completion of slurry pump operations was a value above 0% of the LFL observed in Tank 40 LFL monitor sampling results. The information indicates that the release of hydrogen trapped in the waste tank slurried sludge is not an instantaneous or full release. Even when the tank undergoes trapped gas release activities (e.g., sludge agitation), the percent hydrogen seen in the waste tank vapor space is insignificant (the highest recorded from Tank 40 during and after completion of slurry pump operations was 5% of the LFL). Without waste tank mixing device operation, the release of the hydrogen bubbles would be much slower. Therefore, no additional uncertainty allowances due to trapped gas release need to be applied to the spontaneous time to LFL calculation.

Best management practice will be to limit the Very Slow Generation designation to tanks that reach equilibrium at less than 95% of the LFL_{OC}. For a Very Slow Generation Tank that is found to reach equilibrium at or above 60% of the LFL_{OC}, the tank shall undergo quarterly ventilation operation using an installed or portable ventilation system (i.e., for a duration of 12 vapor space turnovers). As an alternative to ventilation operation, the tank vapor space may be verified to be less than 60% of the LFL. Tank 50, at a minimum of once per year, shall undergo periodic ventilation operation using an installed or portable ventilation system.

6.3 CHEMICAL CLEANING PROGRAM

As a Best Management Practice, the hydrogen LFL limit of 12% should be entered in the ERD for tanks in Acidic Chemical Cleaning Mode. This is a set value for all Chemical Cleaning Tanks based on the purge flow protecting 25% of the LFL [Ref. 34]. This value is not determined using the methodology in this Program, and is not required to be entered in the ERD by the TSRs. However, it should be included in the ERD for clarification.

In addition, the conductivity probe height / tank fill limit for tanks in Acidic Chemical Cleaning Mode should be entered in the ERD [Ref. 2]. This is a set value (61 in. for Type I Tanks, 63 in. for Type II Tanks) [Ref. 6], and was used in the purge flow analysis for Chemical Cleaning Tanks. Although not required to be entered in the ERD by the TSRs, it should be included in the ERD for clarification.

6.4 CONTINGENCY STORAGE

DOE Manual 435.1-1 describes the commitment to have spare capacity with adequate capabilities to receive the largest volume of waste contained in any one storage vessel, pretreatment facility or treatment facility [Ref. 46]. This commitment is implemented by the ETAF process (Ref. 11, Tab Electronic SW11.1); however, when performing a flammability calculation where the HLLCP setpoint is required to be lowered on a Type III/IIIA waste tank, the group responsible for the ETAF process should be notified of the new setpoint to ensure adequate contingency storage is available once the HLLCP is lowered.

6.5 QUIESCENT TIME PROGRAM

For waste tanks where the Seismic Quiescent Time or Spontaneous Quiescent Time is calculated using Equation 53, 54, or 64 (i.e. where the equilibrium hydrogen concentration is less than LFLoc and the initial hydrogen concentration plus trapped gas release is greater than or equal to LFLoc), Best Management Practice will be to round the calculated Q-Time down to the next lower day (e.g., 52.9 days will be rounded to 52 days). This, along with the additional conservatism already included in the Seismic and Spontaneous Quiescent Time methodology (See Section 7.2) is considered to provide sufficient margin to prevent reaching a flammable condition. Additionally, for waste tanks in the condition described above, the tank flammability classification is designated Rapid or Slow, which requires continuous ventilation operation.

7.0 UNCERTAINTIES AND CONSERVATISMS

7.1 SEISMIC TIME TO LFL METHODOLOGY

There are conservatisms associated with the seismic time to LFL methodology; including:

- 100% of the hydrogen generated after the seismic event will not be in the waste tank vapor space after the seismic event. When part of the trapped gas in salt and sludge layers is released after the seismic event, some of the hydrogen generated will tend to be retained to restore the trapped gas inventory to the maximum quantities achieved prior to the seismically induced release.

- Measured (actual) hydrogen generation rates in high-heat waste tanks are significantly less than calculated (theoretical) hydrogen generation rates [Ref. 28].

- The equations used to determine the radiolytic hydrogen generation rate are based on experimental data that has margin added [Ref. 50].

No additional uncertainty allowances are applied to the seismic time to LFL methodology

because of these large conservatisms.

7.2 QUIESCENT TIMES METHODOLOGY

There are several conservatisms that exist in the calculation of quiescent times including:

- All trapped gas that is released upon operation of waste tank mixing devices, or following a seismic event, is assumed to be released instantaneously. This is conservative because actual gas release is known to be a time-dependent phenomenon.
- Gas is retained in a step-wise fashion: 25% retention for an inventory of less than 40 inches of sludge; 50% retention for an inventory of greater than or equal to 40 inches and less than 90 inches of sludge; 75% retention for an inventory of greater than or equal to 90 inches and less than 110 inches of sludge; and 100% retention for an inventory of greater than or equal to 110 inches [Ref. 1]. Actual data shows retention to be a 2nd order polynomial function of sludge depth [Ref. 20].
- Ventilation system operation during waste tank mixing device operation serves to limit the vapor space flammable gas concentration significantly below 25% of the LFL for hydrogen. Routine waste tank mixing device runs with ventilation operating cause the vapor space to reach only 5-10% of the LFL_{OC} [Refs. 25, 46].
- 100% of the hydrogen generated after the waste tank mixing device operation or seismic event will not be in the waste tank vapor space. When the trapped gas in sludge is released after the pump run or seismic event, some of the hydrogen being generated will tend to be retained to restore the trapped gas inventory to the quantities achieved prior to the release.
- The equations used to determine the radiolytic hydrogen generation rate are based on experimental data that has margin added [Ref. 50].

Additional conservatism is included in waste tanks that are not in GRM. The frequency to run pumps to stay out of GRM implemented in the ERD [Ref. 2] is based on the vapor space protected by the HLLCP. Due to these large conservatisms, no additional uncertainty needs to be incorporated into the calculated quiescent times. Slight changes in calculated quiescent times as a result of analytical uncertainty in sample results are incorporated in the ERD [Ref. 2] as new data is input into WCS [Ref. 11] .

8.0 DEVIATIONS

Proposed deviations from the requirements as described by this PDD shall be evaluated as deemed appropriate. The proposed deviation shall be reviewed by the Program Review Committee (PRC). Furthermore, acceptance of the deviation and evaluation and any required compensatory actions shall require documented approval of the PRC.

9.0 REFERENCES

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LW FORM

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Document Number: WSRC-TR-2003-00087 Revision: 34

Document Title: CSTF Flammability Control Program - Program Description Document

The following checklist is required to be completed and attached to the document under review in compliance with Manual E7 and S4 procedures. This list should not be considered all inclusive. Add any additional notes or comments to the end of the checklist.

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	VERSION / FORMAT		
1	If revising an existing document, are you starting with the latest, approved version of the document obtained from SmartPlant Foundation (SPF) or DCR?	Yes	
2	Are all OSR or SPF forms properly and completely filled out and is the current approved version of the form used?	N/A	
3	Does the document format include all of the sections as described in manual E7 and S4 procedures (2.31A ,3.60, etc.)?	Yes	As applicable
4	Are all of the pages properly labeled with Document Number, Revision Number, and Sequential Page/Sheet Number?	Yes	
5	Are the Subject and Purpose clearly stated and do they meet the end-users needs?	Yes	
6	Ensure a document category (Support, General, NTB) has been assigned as required per Manual E7, Procedures 1.05 and 2.31A.	Yes	Support
	REFERENCES		
7	Are all References properly documented within the document and can they be easily verified within Document Control, on-line, or within the library, etc.? If reference documents are not readily available, are they attached?	Yes	
8	Have the correct design bases documents been identified (e.g., Codes, Standards, DOE Orders, SRR Requirements, Regulatory Requirements, DSA)?	Yes	
	OPEN ITEMS / INPUT		
9	If data is transferred from other documents, calculations or sources, is this data correct and applicable?	Yes	
10	Are all inputs found in the body of the document or calculation individually listed and if the document is a calculation, numbered in the Inputs section?	N/A	Not a calculation
11	Is there a reference/source for each input?	N/A	
12	Do the identified references/sources fully support the inputs and does the data meet appropriate quality assurance requirements?	Yes	

OSR 46-574 Rev. 6 6/26/2019	LW FORM **ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST** Procedure Ref. E7-2.31A and S4-ENG.51	Savannah River Site (SRS) Page 2 of 7

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	OPEN ITEMS / INPUT – continued		
13	Have the correct operational and functional requirements of the facility been properly considered?	Yes	
14	Have appropriate operational modes and worse case scenarios been considered?	Yes	
15	Are all assumptions used to support the document individually listed and numbered in the Assumptions section?	N/A	
16	Is there an adequate justification written for each assumption that includes a technical basis?	N/A	
17	If the document is a calculation and there are Open Items, has the calculation been statused as preliminary? Note: A Confirmed calculation cannot have Open Items.	N/A	
18	If the document is a preliminary calculation, have actions required to change the status from "preliminary" to "confirmed" been listed as "open items"?	N/A	
19	If the document has open items, is there a method identified to track them? List tracking numbers in Comments (STAR, POD item number, etc.).	N/A	
	ANALYTICAL METHODS AND COMPUTATIONS		
20	Are the analytical methods and computations clearly spelled out step-by-step?	Yes	
21	Is the analytical approach in use clearly described with justification along with alternative methods?	Yes	
22	Is the methodology consistent with the purpose and objective?	Yes	
23	Are mathematical derivations correct, including dimensional consistency of results?	Yes	
24	Have calculations been checked for errors as applicable per E7-2.31A, Sections 5.3.2.5 and 5.5.1? Where a calculation has multiple iterations of the same computation with numerous input and output values, the Verifier/Checker may select a representative sample of the total input and output values for review.	N/A	
25	Were the analysis inputs correctly incorporated into the analysis and are the outputs reasonable compared to the inputs?	N/A	
26	Is the Summary of Conclusion clearly stated? Does it meet the end-user's needs? Clearly state if results meet/do not meet the Objectives of the analysis?	N/A	
27	Are the numeric values consistent with the appropriate accuracy (significant figures) of the analysis?	N/A	

OSR 46-574 Rev. 6 6/26/2019	LW FORM **ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST** Procedure Ref. E7-2.31A and S4-ENG.51	Savannah River Site (SRS) Page 3 of 7

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	ANALYTICAL METHODS AND COMPUTATIONS – continued		
28	Are safety margins consistent with good engineering practice?	Yes	
28B	If this is an Accident Analysis Calculation, then are methodologies consistent with all relevant supplemental guidance documents located at \\wg08\ABDOC\Supplemental Guidance-Nuclear Safety and AA? Note: Always default to approved procedures and policies when the referenced supplemental guidance appears in conflict. Contact Manager of Nuclear Safety for access to wg08.	Yes	Not an AA calc
	SOFTWARE		
29	Is software (including spreadsheets) used? If NO, then "N/A" this section.	No	
30	Have computer software programs used for calculations been evaluated and properly classified for this activity using OSR form 19-337 (SWCD), per 1Q QAP 20-1 and E7-2.25? Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38. B) The SWCD (software classification document) form is a site-wide application in Lotus Notes.	N/A	
31	Is computer software used for the analysis being controlled per E7-2.31A, Section 5?	N/A	
32	Were appropriate analysis methods and computer methods used?	N/A	
33	If a computer program or model is used in the calculation, is it used within the range of validity, or is use outside the range of established validity justified?	N/A	
34	Was the software program used within any restriction, criteria or test frequency requirements in the Software Quality Assurance Plan? (SQAP) (e.g., computer operating system/platform criteria, software within testing frequency).	N/A	
35	Is the software used noted on the Calculation cover sheet and referenced appropriately in the calculation?	N/A	

OSR 46-574 Rev. 6 6/26/2019	LW FORM **ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST** Procedure Ref. E7-2.31A and S4-ENG.51	Savannah River Site (SRS) Page 4 of 7

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	SOFTWARE – continued		
36	If the calculation supports the DSA, is the software and version used on the SSIL (Safety Software Inventory List) when required? Provide explanation in Comments. Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38 B) The SSIL is updated on an annual basis so recently approved SQAPs may not be added to the SSIL until the next annual update.	N/A	
37	Are the equations shown in the calculation, including example functions where Excel spreadsheets or MathCad is used?	N/A	
38	If using general-purpose commercially available software as described in E7-2.31A, Section 5.5.1, then answer YES and describe checking method (5.5.1.2.C 1, 2, or 3) in Comments	N/A	
39	Have computer program error reports been checked for potential effect on the analysis?	N/A	
	RESULTS / CONCLUSIONS		
40	Are the results of the document consistent with the input and assumptions?	N/A	
41	Do the results of the document affect any other technical documents?	N/A	
42	Do the results substantiate the conclusion?	N/A	
	APPROVALS		
43	Does the document identify the method of verification, if applicable, and does it have a signature block for the verifier/checker?	Yes	

Checker: K.M. Welsh / [signature] Date: 11/7/19
Print Signature

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Item No. Cont.	Comment Continuation

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Items 44-56 are only to be completed when Verification by Document Review is being performed. The verifier assures the technical accuracy of the document by performing administrative and mathematical checks as appropriate, and by evaluating the document against the following questions:

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
44	Were the inputs correctly selected and identified?	N/A	
45	Are the assumptions made in the performance of the design or analytical activity adequately described and reasonable?	N/A	
46	When necessary, are the assumptions identified for subsequent re-verification when the detailed design activities are completed?	N/A	
47	Were appropriate design or analytical methods and computer programs used?	Yes	
48	Were the design or analytical inputs correctly incorporated into the design, analysis or evaluation?	Yes	
49	Have engineering actions required to support risk handling strategies been verified?	Yes	
50	Is the design output reasonable compared to the design or analytical inputs?	N/A	
51	Are the necessary design inputs for interfacing organizations specified in the design documents or in supporting procedures or instructions?	N/A	
52	Have suitable materials, parts, processes, and inspection and testing criteria been specified?	N/A	
53	Have existing and potential workplace hazards been identified, evaluated, and controls incorporated for the risk to worker injury or illness?	N/A	
54	Was a review conducted to confirm that there are no interferences with other ongoing or planned modifications?	N/A	
55	Have engineering judgments been identified, technically justified, and supported?	Yes	
56	Have design optimization strategies been considered / met (e.g., appropriate tailoring of requirements, design attributes, and operating strategies)?	Yes	

Verifier: K.M. Welsh / [signature] Date: 11/7/19
Print Signature

OSR 46-574 Rev. 6 6/26/2019	LW FORM **ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST** Procedure Ref. E7-2.31A and S4-ENG.51	Savannah River Site (SRS) Page 7 of 7

Item No. Cont.	Comment Continuation

Savannah River Remediation

WSRC-TR-2003-00089
Rev. 12

CSTF Sludge Carryover Minimization Program

Program Description Document

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Summary of Revisions

	Revision 0	Initial Issue
03/03	Revision 1	Reworded description of output documents in Section 4.0
05/03	Revision 2	Addressed placement of the feed pump recycle line.
11/06	Revision 3	Includes minor editorial changes. Removes references to RBOF. Revises the author of the TCP PDD in Ref.1. Remove key attribute "The pump or jet zone of influence", and adds the ability to continue transfers into an evaporator feed tank should the separation distance between the inlet downcomer and the sludge level is found to be less than 36 inches.
4/08	Revision 4	Removed Tank 33 from those tanks requiring annual sludge soundings. 221F is no longer sending sludge material to Tank 33. Reformatted document to improve clarity and consistency in formatting. Added Tank 47 to tanks exempted from program. Tank 47 converted to drop tank and salt layer protects sludge layer. Updated references. Performed minor editorial changes.
3/09	Revision 5	Split the three feed tanks out from one section to three subsections to provide clarity in application of implementation items. Added the following reports/studies associated with sludge disturbance in feed tanks: Britt, T. E., Estimated Impact of a Liquid Addition to Tank 22H through a Side-Wall Penetration, G-ESR-H-00091, Rev. 0 to clarify the discussion of transfer into the feed tank from a side wall penetration; Tank 26 Evaporator Feed Pump Transfer Analysis, SRNS-TR-2008-00026, Rev. 1 to allow feed pump operation during transfers into feed tank through short downcomer; Tank 32 Evaporator Feed Pump Transfer Analysis, SRNL-TR-2008-00324, Rev. 0 to allow feed pump operation during transfers into feed tank through short downcomer. Added controls on levels for Tank 26, 32, and 43 to capture inputs of above studies. Added section addressing methods of sludge measuring (i.e., wafer or turbidity meter) to be used to determine sludge interface. Reformatted document to improve overall clarity. Removed Tank 23 from outside

		facilities section (no longer receiving RBOF transfer). Removed Tank 38 from outside facilities section (Tank38 has no sludge level; Tank 43 Evaporator Feed Qualification controls preclude introduction of Tank 43 sludge into Tank 38). Annual sludge measurements of feed tanks moved from outside facilities requirement to evaporator feed tank requirements (better fit).
6/11	Revision 6	Added Tank 49 to Table 1. Section 4.2: Added engineering evaluation option to calculate the sludge height. Section 4.3.1 clarified that the solids loading is an order of magnitude less than the limit. Section 4.5: Deleted Tank 21 from DWPF recycle receipts. Section 5.0: Corrected and updated several references. Added Reference 38. Deleted unused references.
4/13	Revision 7	Revised Section 4.1 to delete "REMOVED FROM SERVICE MODE" and change "Tanks 17 and 20" to "Tanks 17 thru 20". Updated references 4 and 16.
6/14	Revision 8	Revised "evaporator feed pump is isolated" to "evaporator feed pump is secured" throughout the document, Section 4.2.1 added requirement to document non-preferred method, Section 4.4.2.a.i clarification added to engineering evaluation, Revised Section 4.5 to change Tank 22 turbidity measurement frequency from annual to quarterly, change Tank 39 turbidity measurement frequency from quarterly to semi-annual and added quarterly frequency for Tank 13, 41 as needed. Updated references
3/16	Revision 9	Revised Sections 4.0, 4.1, 4.2, 4.3, 4.4 for Trapped Gas PISA changes in DSA, Revised Sections 4.0, 4.1.3, 4.3.1 to incorporated STAR 2015-CTS-011760, OFI Action item 2, Revised Section 4.3.3 to delete the action items for 2F evaporator feed tank (Tank 26) since feed pump, transfer jet/deflector is removed from the tank. Revised Section 4.5 to update outside facilities inflow and sludge measurement frequencies, and updated Section 5.0 references.
10/17	Revision 10	Section 4.5: Revised estimated sludge slurry volume per batch from 650 gallons to 200 gallons based on DWPF WCP revision (U-ESS-G-00007).

11/17	Revision 11	2017 DSA Annual Update: Section 4.1.1, added Tank 12 as exemption, Section 4.3.3 is deleted since 2F evaporator is not a Process Area, added document number to Reference 11.
6/18	Revision 12	2018 DSA Addendum (Operation of the 242-25H Evaporator with Leak Sites): Updated the following sections: 3.1, 4.1.2, 4.3, 4.3.2, & 4.3.3

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1.0 PURPOSE

The purpose of this program is to provide the implementation strategy for the CSTF Sludge Carryover Minimization (SCOM) Program. The Program defines the programmatic controls that minimize the amount of sludge solids carried over for supernate and evaporator feed/bottoms transfers. In addition, the Program defines the criteria that designate a WASTE TRANSFER as SLUDGE SLURRY TRANSFER in support of the Transfer Control Program (Reference 16). The Program defines the periodicity of sludge level measurements based on the level of activity of the tank (e.g., transfers in/out, agitation via mixing devices).

The output documents generated by this Program shall ensure independent verification or validation of results and conclusions. Output documents include, but are not limited to, calculations, procedures, and technical reports.

Calculations issued as output documents shall be confirmed Type I calculations in accordance with the requirements of the E7 Manual, Procedure 2.31. Technical Reports issued as output documents shall comply with the requirements of E7 Manual, Procedure 3.60. Assumptions and recommendations from these reports shall be addressed in the Design Authority Technical Review (DATR) written against the Proposed Activity. Additionally, the output documents will be included in the USQ review process against the Proposed Activity per Manual 11Q, Procedure 1.05.

Proposed deviations from implementation requirements and action items as described in this PDD shall conform to the requirements of S4 Manual Procedure ENG.36.

1.1 PDD Owner Qualifications:

The qualifications for PDD ownership are established in S4 Manual Procedure Eng.36.

1.2 PDD Owner Responsibilities:

The PDD Owner Responsibilities are established in S4 Manual Procedure Eng.36.

2.0 SCOPE

The scope of this Program Description Document (PDD) is to provide guidance to engineering and operational personnel for implementing SCOM related controls contained in the Documented Safety Analysis (DSA) programs and Technical Safety Requirements (TSR) Administrative Controls (ACs) in transfer procedures, transfer evaluations and approval procedures. This document is not a Safety Basis document.

Revision 12 of this PDD supports changes associated with the DSA Addendum: Operation of the 242-25H Evaporator with Leak Sites.

3.0 BACKGROUND

3.1 Safety Function:

The safety function of CSTF Sludge Carryover Minimization (SCOM) Program is to protect the bounding initial assumption of a maximum 1 wt.% sludge carryover for supernate transfers and evaporator feed/bottoms transfers associated with the 242-16H evaporator (Reference 4, Section 3.4.1.5.1). It also implements some of the 16H Evaporator Enrichment Control Program (ECP) (Reference 12, Section 4.3.2) requirements. However, ECP requirements are presented in Reference 12 and SCOM PDD is cross- referenced for implementing action items. Also methodology to estimate sludge volume to be transferred during SLUDGE SLURRY TRANSFERS is included in this document to meet Flammability Control Program PDD requirements (Reference 11). Furthermore, as discussed in DSA Addendum Section 3.3 [Ref. 6], the 242-25H Evaporators Bottoms waste stream (and associated feed streams) inhalation dose potential limit has been updated to 1.85E+07 rem/gal (this value does not include uncertainty). Based on this change to the waste stream definition, protecting 1 wt.% sludge solids (via this PDD) does not necessarily ensure compliance with the revised 242-25H Evaporator Bottoms (and associated feed) inhalation dose potential limit of 1.85E+07 rem/gal (this value does not include uncertainty). Therefore, an engineering evaluation will be required to ensure compliance with the inhalation dose potential limit for 242-25H Evaporator Bottoms (and associated feed).

This program protects bounding initial assumptions (e.g., Material at Risk) for applicable DSA Chapter 3 events.

4.0 PROGRAM DESCRIPTION

Suction of transfer devices (pumps and jets) shall be a minimum of 24 inches from the sludge layer to minimize sludge entrainment during supernate transfers including feeding the Evaporators). (SAC) (TSR 5.8.2.19) (Reference 1)

Additional controls shall be implemented as necessary to minimize the amount of sludge solids carried over in supernate transfers based on evaluation of the following phenomena:

- Tank Agitation
- Effects of receiving WASTE TRANSFERS concurrent with an out-going transfer

This section of the Program is divided into five subsections that address the following: 1) identification of exemptions to the Program, 2) identification of the methods to measure sludge level, 3) Program controls for evaporator feed tanks, 4) Program controls for

transfers between waste tanks, and 5) Program controls for receipts from outside facilities.

4.1 Inputs:

4.1.1 Program Exemptions

The following are exempted from this Program:

- Tank 48 is exempt from this Program since transfers into or out of Tank 48 are prohibited.
- Non-waste transfers are exempt from this Program.
- Waste tanks that are closed (e.g., Tanks 5, 6, 12 and 16 thru 20) are exempt from the Program.
- Salt tanks are exempt from the Program. Salt tanks are defined as those waste tanks in which no sludge layer lies between the supernate and the saltcake. Waste tanks that meet the definition of salt tanks are identified in Table 1.

Table 1: Waste Tanks Identified as Salt Tanks (1)	
F-Tank Farm	1, 2, 3, 25, 27, 28, 44, 45, 46, and 47
H-Tank Farm	9,10, 14, 29, 30, 31, 36, 37, 38, and 49

(1) *If a salt tank receives a sludge transfer on top of the salt layer, then exemption from this Program no longer applies to the listed tank.*

- Tank 50 is exempt from this program since transfers in and out of Tank 50 are non-waste transfers and IDP greater than 2.09E+05 rem/gallon are prohibited by TSR Section 5.8.2.43.u. Since transfers out of Tank 50 are a non-waste transfers, there is no need to distinguish between supernate and SLUDGE SLURRY TRANSFER.

4.1.2 Sludge Level Measurement

Several DSA analyzed waste streams include 1.0 wt.% maximum sludge content. The 1.0 wt.% maximum sludge is considered to be conservative based upon the nature of the processes Sludge levels are routinely determined by measurement, visual inspection or by engineering evaluation. However, the DSA Addendum Section 3.3 [Ref. 6], updated the 242-25H Evaporators Bottoms waste stream (and associated feed streams) inhalation dose potential limit to 1.85E+07 rem/gal. Based on this change to the waste stream definition, protecting 1 wt.% sludge solids

(via this PDD) does not necessarily ensure compliance with the revised 242-25H Evaporator Bottoms (and associated feed) inhalation dose potential limit (1.85E+07 rem/gal). Therefore, an evaluation is required to ensure compliance with this inhalation dose potential limit for the 242-25H evaporator.

Sludge level determinations are performed and the results are entered into operating procedures. Data entered into Waste Characterization System (WCS) in accordance with the WCS Program requirements. Uncertainties in sludge level determination and pump/jet placement are conservatively accounted for in the margins discussed in the DSA.

Sludge soundings provide an accurate level indication of the settled sludge layer. However, in a waste tank in which the sludge layer has been disturbed by the agitation of transfers of liquid into the waste tank or mixing device operation, a layer of suspended solids may be present for some period above a settled sludge layer. This turbid region can exceed 1 wt.% sludge content. In cases where a turbid region is likely to exist, the turbidity meter is the preferred method for sludge level determination. The turbidity meter sensitivity and accuracy must be such that the meter will identify a turbid region of 1 wt.% or less solids. This level of meter sensitivity and accuracy will ensure the supernate requirement of 1.0 wt.% maximum sludge content is protected. (Reference14). Visual inspections may be by direct observation or via camera by comparison to the known waste tank component elevations. Engineering evaluations for sludge level determination shall address the following for the specific waste tank: process knowledge (e.g., transfer history, operational conditions), historical sludge level indications, waste tank sample results and uniformity of the solids level (settled sludge / slurried sludge) as described below:

It is recognized that the solids layer (settled sludge / slurried sludge) level within a waste tank may not be at a uniform level across the tank (e.g., layer slopes downward from one side of the tank). The engineering evaluation shall consider this in determining the solids layer volume from the level determination. Although the highest measured or visually determined value may be used to define the level of the entire layer, this may produce an unreasonably conservative value for use in determining the required pump/jet suction location. Known parameters of the layer (e.g., approximate slope of a settled sludge layer, mapping) may be utilized to estimate a more reasonable actual level of the layer in relationship to determining the required pump/jet suction location.

4.1.3 Selection of Sludge Level Measurement Technique

Sludge level is calculated based on measurement by sludge soundings or turbidity meters, visual inspection or engineering evaluation. The method

of measurement is determined by Engineering. Preferred method for slurried sludge tanks and sludge tanks that received transfers within the last year is turbidity measurement and will be documented in SW11.1-WTE-7.2 procedure. However, if the tank has only settled sludge and no transfers are received within the last year, sludge sounding is the preferred method. If the preferred method is not used, an engineering evaluation shall be performed for using non-preferred method.

The calculations performed to determine sludge level and the verification of separation distance between sludge level and pump/jet suction location shall be independently verified. An operational check of the turbidity meter is required prior to its use in measuring sludge level.

1. Requirement: Engineering must specify the preferred sludge measurement method in SW11.1-WTE-7.2.

    a. Preferred method for slurried sludge tanks and sludge tanks that received transfers within the last year is turbidity measurement.

    b. Preferred method for settled sludge tanks that received no transfers within the past year is sludge sounding.

    c. If a non-preferred method of sludge measurement is used, an engineering evaluation shall be performed.

2. Requirement: The calculations performed to determine sludge level and the verification of separation distance between sludge level and pump/jet suction location require independent verification.

3. Requirement: An operational check of the turbidity meter is required prior to its use in measuring sludge level.

4.2 Key Attributes

In order to minimize the carryover of sludge, the interaction of the upper portion of the sludge layer and the transfer pump or jet should be minimized. Controls are imposed on the transfer pump/jet suction heights for selected WASTE TRANSFERS to minimize entrainment of sludge during supernate transfers. The Sludge Carryover Minimization Administrative Control Program describes the requirements for the following key attributes:

- Pump or jet suction height versus the sludge level
- Pump or jet agitation of the sludge
- Concurrent sludge slurry waste receipts and supernate transfers
- Concurrent sludge agitation and supernate transfers

Transfers not meeting this program are considered as SLUDGE SLURRY TRANSFERS. Additionally, for transfers that do not meet the Sludge Carryover Minimization Program PDD separation criterion, receipt waste tanks are evaluated for entry into the Spontaneous Liberation Protection portion of the Waste Tank Quiescent Time Program per Flammability Control Program PDD (Reference 11).

4.3 Evaporator Feed Tanks

The 242-16H evaporator feed waste stream was evaluated in the DSA including 1.0 wt.% maximum sludge content. This Program protects the 1.0 wt.% maximum sludge content in the 242-16H evaporator feed stream.

As discussed in DSA Addendum Section 3.3 [Ref. 6], the 242-25H Evaporators Bottoms waste stream (and associated feed streams) inhalation dose potential limit has been updated to 1.85E+07 rem/gal (this value does not include uncertainty). Based on this change to the waste stream definition, protecting 1 wt.% sludge solids (via this PDD) does not necessarily ensure compliance with the revised 242-25H Evaporator Bottoms (and associated feed) inhalation dose potential limit (1.85E+07 rem/gal). Therefore, an engineering evaluation will be required to ensure compliance with the inhalation dose potential limit for 242-25H Evaporator Bottoms (and associated feed).

Sludge levels can be determined by the methods recommended in Section 4.2. (e.g., sludge soundings, turbidity measurements, visual inspection or engineering evaluation). Settled sludge has a relatively flat profile across the entire tank based on historical observations of dry sludge tanks and Extended Sludge Processing operations. Some mounding is expected beneath the waste influent line. Therefore, to obtain the most representative sludge level, measurements should be conducted between the waste influent line and the feed pump riser or within the same tank quadrant as the feed pump riser. The 24-inch separation requirement provides margin for uncertainties in the Computational Fluid Dynamics (CFD) models and the capability to determine the sludge level in the waste tanks. CFD studies have shown that a feed pump placed 9 inches above the sludge layer would result in entraining 1% of the flow from the hindered settling region (Reference 7). If the sludge level determinations cannot be conducted in the tank locations described above, then an additional 12 inch margin will be added to the separation requirement to account for possible sludge level sloping. Table 2 identifies the evaporator feed tanks as well as the applicable sections of this Program.

Table 2: Evaporator Feed Tanks		
Evaporator	**Feed Tank**	**Applicable Implementation and Actions Sections**
2H	Tank 43	4.3.1; 4.4
3H	Tank 32	4.3.2, 4.3.3; 4.4

4.3.1 Tank 43 Implementation Requirements and Actions

Tank 43 WASTE TRANSFER operations must be monitored to ensure sludge solids disturbance is minimized. The monitoring, in addition to supporting this Program, supports aspects of the Evaporator Feed Qualification Program (Reference 12).

Tank 43 receives WASTE TRANSFERS through either a submerged "Tee" downcomer assembly or an open side wall penetration. There are no restrictions for concurrent evaporator feed operations and supernate transfers into Tank 43 when the transfer is through the "Tee" downcomer (Reference 9) and the implementation actions below are met. This is because the combination of horizontal discharge, a relatively low exit velocity, and the absence of any established recirculation paths indicate insignificant mixing of the sludge turbidity zone.

Assessments of the impingement of jets introduced into sludge containing waste tanks have shown that the sludge solids in a waste tank with a minimum of seven feet (84 inches) of liquid coverage are not disturbed (Reference 2). The analysis results show that, for the minimum tank liquid level of 84” inches above the sludge layer, the evaporator feed pump will contain less than 0.1 wt% sludge solids in the discharge stream (Reference 38). This value is an order of magnitude less than the 1.0 wt% sludge solids loading criteria to feed the evaporator. Therefore, a control must be placed on Tank 43 liquid level requiring 84 inches of supernate coverage of a sludge layer during supernate transfers through waste tank sidewall penetrations (e.g., Tank 38 to Tank 43 recycle transfer) to prevent sludge entrainment into the evaporator feed.

By establishing, the separation distance between the sludge layer and the evaporator feed pump/eductor suction, the discharge of the bypass valve

of the Tank 43 feed pump (i.e., the feed pump recycle line) is bounded by this distance. Thereby, compliance with the separation distance between the sludge and potential sludge disturbing operations is maintained (Reference 5, 15, 19, and 28).

1. Requirement: The minimum separation between the Tank 43 evaporator feed pump suction and the sludge layer is 24 inches, AND the Tank 43 evaporator feed pump recycle discharge line must be a minimum of 24 inches above the sludge layer (Reference 12).

    a. Establish a baseline sounding/turbidity distance between the waste influent line discharge and the feed pump riser OR in the same quadrant as the feed pump riser, AND verify the separation distance is greater than or equal to 24 inches.

    b. If the sludge sounding/turbidity was conducted from another location in the tank; THEN verify the separation distance is greater than or equal to 36 inches.

    c. If the separation distances above are not met for Tank 43, the evaporator feed pump must be secured until the minimum separation distance is restored and documented in SW11.1-WTE procedure. Influent transfers can continue if the evaporator feed pump is secured.

    d. Tank 43 sludge level shall be rebaselined annually.

2. Requirement: All influent waste streams into Tank 43 shall be positioned at greater than or equal to 36 inches above the sludge layer (Reference 12).

    a. Establish a baseline separation distance between the Tank 43 sludge layer and the waste influent downcomer discharge level and document the distance in the SW11.1-WTE procedure, AND verify the separation distance is greater than or equal to 36 inches.

    b. If the separation distance above is not met for Tank 43, the evaporator feed pump must be secured until the minimum separation distance is restored and documented in SW11.1-WTE procedure. Influent transfers can continue if the evaporator feed pump is secured.

3. Requirement: All influent liquid streams into Tank 43 through a side wall penetration shall have greater than or equal to 84 inches of liquid (e.g., supernate) covering the sludge layer.

    a. Prior to performing a liquid transfer into Tank 43 through a sidewall penetration (e.g., Tank 38 to Tank 43 recycle

transfer), verify ≥ 84 inches of liquid coverage of the sludge layer.

b. If the 84 inches of coverage is not met for Tank 43, THEN

i. The Tank 43 evaporator feed pump must be secured to perform the liquid addition through a side wall penetration.

ii. The separation distance requirements given in item 1 above must be restored and documented in SW11.1-WTE procedure prior to feed pump operation.

4. Requirement: The Tank 43 evaporator feed pump shall be shutdown prior to performing a SLUDGE SLURRY TRANSFER into Tank 43, or an engineering evaluation, demonstrating the required separation will not be impacted, may be performed prior to the transfer in lieu of shutting down the feed pump.

If a transfer into Tank 43 is designated as a SLUDGE SLURRY TRANSFER, THEN

An engineering evaluation must be completed prior to the SLUDGE SLURRY TRANSFER that demonstrates the sludge slurry addition will not impact the separation requirements of item 1 above. The evaluation must address the sludge settling times and the applicability of sounding or turbidity meters in the verification of compliance with the separation requirements. The evaluation must also confirm that the solids concentration wt% solids and IDP sent to the evaporator during and after the transfer is within the DSA assumed limits (< 1wt% or 3.3E+07 rem/gal).

OR

Shut down the Tank 43 Evaporator Feed Pump prior to the SLUDGE SLURRY TRANSFER, and the separation distance requirements given in item 1 above must be restored and documented in SW11.1-WTE procedure prior to feed pump operation following the completion of the SLUDGE SLURRY TRANSFER.

4.3.2 Tank 32 Implementation Requirements and Actions

Tank 32 WASTE TRANSFER operations must also be monitored to ensure sludge solids are not disturbed. This monitoring, as previously discussed, supports the Programs purpose of protecting the 242-25H Evaporator Bottoms and Feed stream inhalation dose potential.

Tank 32 receives liquid additions through a "short" downcomer assembly located near the top of the waste tank (References 5, 17, and 23). A Computational Fluid Dynamics (CFD) analysis of Tank 32 was performed analyzing the sludge solids carried over to the 3H evaporator by the Tank 32 feed pump during a supernate transfer into the Tank 32 through a "short" downcomer (Reference 22). The analysis results show that, for the minimum tank liquid level of 105 inches above the tank bottom (which corresponds to a liquid depth of 74.4 inches above the sludge layer), the evaporator feed pump will contain less than 0.1 wt% sludge solids in the discharge stream. Lower liquid levels with respect to the sludge layer will result in higher amounts of sludge entrainment due to the increased plunging jet velocity from the downcomer disturbing the sludge layer. Higher liquid levels (>105 inches above the tank bottom) would yield decreased plunging jet velocities. It should also be noted that the CFD evaluated a free-falling jet with little diffusion during the fall. It has been observed through cameras placed in waste tanks that liquid additions through the "mailbox" style downcomer defuse significantly. The diffusion of the stream distributes the force of the falling stream over a larger area and results in a lower penetration into the liquid on impact and less disturbance and mixing than the falling jet in the analysis.

In order to retain the validity of the CFD findings, the following inputs and assumptions of the analysis shall be controlled to allow evaporator feed pump operations during transfers into Tank 32:

- Tank 32 level must be ≥ 105 inches from the bottom of tank
- At least 74.4 inches of liquid must cover the Tank 32 sludge layer.

1. <u>Requirement:</u> DSA Addendum Section 5.5.4.2.48 [Ref. 6] states the 242-25H Evaporator Bottoms and Feed inhalation dose potential limit of 1.85E+07 rem/gal (this value does not include uncertainty) has to be met.

    a. A sample shall be pulled and an engineering evaluation shall be performed as a baseline to ensure compliance with the inhalation dose potential limit prior to transferring in to the 242-25H Evaporator system.

2. <u>Requirement:</u> For all influent waste streams into Tank 32, the Tank 32 sludge layer must be covered by ≥ 74.4 inches of liquid

(e.g., supernate), AND the Tank 32 level shall be ≥ 105 inches above the bottom of the tank.

a. Prior to transferring into Tank 32, THEN

i. Verify the sludge layer has ≥ 74.4 inches of liquid coverage, AND

ii. Verify Tank 32 level is ≥ 105 inches from bottom of tank,

b. If the sludge layer is covered by < 74.4 inches of liquid for Tank 32 OR Tank 32 level is < 105 inches from the bottom of the tank during a transfer into the tank, THEN

i. Shut down the Tank 32 evaporator feed pump.

ii. Prior to restarting the evaporator a sample shall be pulled and an engineering evaluation is required to ensure compliance with the inhalation dose potential limit.

3. Requirement: The Tank 32 evaporator feed pump shall be shutdown prior to performing a SLUDGE SLURRY TRANSFER into Tank 32.

If a transfer into Tank 32 is designated as a SLUDGE SLURRY TRANSFER, THEN

An engineering evaluation must be completed prior to the SLUDGE SLURRY TRANSFER that demonstrates the sludge slurry addition will not impact the inhalation dose potential limit requirements of 1 above. The evaluation must address pulling the sample in Tank 32 following the sludge slurry transfer to prove 242-25H Evaporator system inhalation dose potential limit requirements will be met.

This sample must be pulled following a predetermined settling time. The sample must confirm that the IDP sent to the evaporator is within the DSA limit of 1.85E+07 rem/gal (this value does not include uncertainty)..

4.3.3 3H System Tanks Inhalation Dose Potential

1. Requirement: DSA Addendum section 5.4.5 states that the 242-25H evaporator bottoms/feed waste streams and associated inhalation dose potential have been updated. Based on this change to the waste stream definition, protecting 1 wt.% sludge solids (via this PDD) does not necessarily ensure compliance with the revised

242-25H evaporator bottoms inhalation dose potential limit of 1.85E+07 rem/gal (this value does not include uncertainty).

a. Incoming supernate transfers into the 3H system (Tanks 30, 32, & 37) shall meet the 1.85E+07 rem/gal limit (this value does not include analytical uncertainty). The transfer tank supernate source term shall initially be based on the calculated 1 wt.% sludge solids carryover limit. If this limit is not met than an engineering evaluation is allowed to justify a lower inhalation dose potential.

b. To address the potential impact of sludge solids accumulation in the 3H system tanks resulting from supernate transfers into Tanks 30, 32, and 37 the following sampling protocol is required to be followed. Samples shall be pulled 24 inches below the pump/jet suction. If there is a solids layer between pump/jet suction and the 24 inch separation then the sample shall be pulled at the solid surface. The sample shall be analyzed for the inhalation dose potential requirements (e.g. absence of sludge solids, less than 242-25H evaporator inhalation dose potential limit, etc). These samples shall be pulled on a semi-annual frequency for these three waste tanks. The nature of these samples (desired depth, frequency, etc.) are similar to the EFQ depth sample requirements already in place [Ref. 8]. Therefore, the EFQ depth samples will meet this new sampling requirement. Tank 30 and Tank 37 sample results will be used to address potential accumulation of sludge solids. Tank 32 sample results and coupled evaluation will be documented in the ERD (Table G-10) to support 242-25H Evaporator start up.

4.4 Transfers Between Waste Tanks

As previously discussed, suctions of transfer devices (pumps and jets) shall be a minimum of 24 inches from the sludge layer to minimize sludge entrainment during supernate transfers. Computational Fluid Dynamics (CFD) studies have shown that a transfer jet or pump placed 11 inches above the sludge layer would result in entraining 1% of the flow from the hindered settling region (Reference 7). The background for the determination of sludge levels is discussed in the previous subsections and is applied to this subsection as well.

In slurried waste tanks (e.g., Tanks 40 and 51) during sludge processing with slurry pumps routinely operating, the sludge will settle uniformly, and there should be very little variation in turbid sludge level across the profile of the waste tank. Therefore, it is permissible in slurried waste tanks (e.g., Tanks 40 and 51) to

exempt the requirement for the additional 12 inches of separation when turbid sludge level is measured outside the pumping device quadrant.

The sludge content of solidified saltcake is minimal (Reference 10 and 20). Therefore, no separation distance restrictions apply for supernate transfers from salt tanks. However, if a salt tank receives a sludge transfer on top of the salt layer then this exemption does not apply.

Concurrent transfers into and out of a waste tank are not allowed without an engineering evaluation that verifies the sludge solids layer will not be disturbed. The evaporator feed tanks are exempted as described in Section 4.3.

After a supernate transfer into a waste tank containing a sludge layer, the separation distance requirements must be demonstrated either by documented engineering evaluation or by rebaselining the sludge level. An evaluation is an acceptable alternative, because no additional solids are being added to the tank, only the potential for entrainment of existing sludge that may not settle before it enters the transfer device zone of influence.

After a SLUDGE SLURRY TRANSFER into any waste tank is conducted, the receipt tank must be rebaselined and successfully achieve the separation distance requirements before the SLUDGE SLURRY TRANSFER designation can be removed for transfers out of that tank.

Transfers out of waste tanks undergoing mechanical mixing (e.g., slurry pumps) are designated as SLUDGE SLURRY TRANSFERS until the mixers are secured and the separation distance requirements rebaselined and successfully achieved.

Reference 46 baselined all waste tanks with settled sludge and slurried sludge levels as required by DSA revision 18. If a WASTER TRANSFER does not meet this PDD's separation criteria for supernate transfer, it shall be designated as a SLUDGE SLURRY TRANSFER. Sludge volume to be transferred will be determined based on pump/jet suction with respect to sludge layer level. Using the methodology in Reference 47, the following criteria can be used to provide a conservative estimate of the sludge volume to be transferred for SLUDGE SLURRY TRANSFER prior to the transfer.

- If pump/jet suction is above settled sludge layer but within 24 inches:
    - Volume of sludge within a sphere with a 24 inch radius of the suction will be transferred.
    - The sludge can be considered as settled sludge if the receipt tank is a settled sludge tank.
- If pump/jet suction is above slurried sludge layer but within 24 inches:
    - All slurried sludge volume within 4 inches of pump/jet suction, if applicable, PLUS

  - Lower of 30% of remaining slurried sludge volume within 24 inches of pump/jet suction OR 30% of total transfer volume as slurried volume.
  - The total amount of sludge transferred is not to exceed transfer volume and shall be considered as slurried sludge in the receiving tank.

- If pump/jet suction is within slurried sludge layer:
  - All slurried sludge volume above pump/jet suction PLUS
  - All slurried sludge within 4 inches of pump/jet suction PLUS
  - Lower of 30% of remaining slurried sludge volume within 24 inches of pump/jet suction OR 30% of total transfer volume as slurried volume.
  - The total amount of sludge transferred is not to exceed transfer volume and shall be considered as slurried sludge in the receiving tank.

- If pump/jet suction within slurried sludge layer and with settled sludge layer within 24 inches of pump/jet suction:
  - All slurried sludge volume above pump/jet suction PLUS
  - All slurried sludge within 4 inches of pump/jet suction PLUS
  - Lower of 30% of remaining slurried sludge volume within 24 inches of pump/jet suction OR 30% of total transfer volume as slurried volume PLUS
  - Volume of settled sludge within 24 inch radius sphere from the pump/jet suction.
  - The total amount of sludge transferred is not to exceed transfer volume and shall be considered as slurried sludge in the receiving tank.

- If pump/jet suction within settled sludge layer with a caisson:
  - All slurried sludge volume above pump/jet suction PLUS
  - Volume of settled sludge within 24 inch radius sphere from the pump/jet suction.
  - The total amount of sludge transferred is not to exceed transfer volume and shall be considered as slurried sludge in the receiving tank.

Alternatively, an engineering evaluation can be performed to determine the transferred sludge volume by using the attributes such as engineering principles (e.g., fluid flow mechanics), engineering modeling (e.g., Computational Fluid Dynamics), equipment characteristics (e.g., pump curves, suction orientation) or process knowledge (e.g., weight percent solids from sample at a specific level) as applicable.

The transferred sludge volume will be used to calculate Flammability Control Program PDD (Reference 11) requirements.

1. Requirement: Suction of transfer devices (pumps and jets) shall be a minimum of 24 inches from the sludge layer to minimize sludge entrainment during supernate transfers.

    a. Establish a baseline sounding/turbidity distance in the same quadrant as the transfer device riser, AND verify the separation distance is greater than or equal to 24 inches.

    b. If the baseline sludge sounding/turbidity measurement was conducted from another location in the tank; THEN verify the separation distance is greater than or equal to 36 inches or provide an engineering evaluation to show that the sludge entrainment is less than 1 wt% to consider as supernate transfer.

        i. Exception: If the waste tank is frequently slurried and well mixed (e.g., Tank 40 and 51), then the separation distance only has to meet 24 inches regardless of which riser is used for the sludge measurement.

2. Requirement: Additional controls shall be implemented to minimize the amount of sludge solids carried over in supernate transfers based on evaluation of the tank agitation (e.g., slurry pump operation, transfers into tank), and the effects of receiving WASTE TRANSFERS concurrent with an out-going transfer. An engineering evaluation can be completed prior to a transfer into a sludge waste tank, which demonstrates that the transfer will not disturb the sludge layer.

    a. Following receipts of SLUDGE SLURRY TRANSFERS into a waste tank,

        i. The separation distance requirements given in item 1 above must be restored and documented in SW11.1-WTE procedure or a technical report must be completed prior to the SLUDGE SLURRY TRANSFER that demonstrates the sludge slurry addition will not impact the separation requirements of item 1 above. The evaluation must address the sludge settling times and the applicability of sounding

or turbidity meters in the verification of compliance with the separation requirements, wt% solids and IDP limits.

ii. If the separation distance requirement is not verified or is not met, or a technical report is not provided, then designate transfers out of the waste tank as SLUDGE SLURRY TRANSFERS in the SW11.l-WTS procedure. SLUDGE SLURRY TRANSFERS must meet the requirements of the Transfer Control Program (Reference 16). Additionally, for transfers that do not meet the Sludge Carryover Minimization Program PDD separation criteria, receipt waste tanks are evaluated for entry into the Spontaneous Liberation Protection portion of the Waste Tank Quiescent Time Program per Flammability Control Program PDD (Reference 11).

b. During mechanical mixing (e.g., slurry pump operation) in a waste tank containing a sludge layer, all transfers out of the waste tank undergoing mixing will be designated as SLUDGE SLURRY TRANSFERS. Mechanical mixing is initiated when the first mixing device (e.g., slurry pump) is started.

c. Following mechanical mixing (e.g., slurry pump operation) in a waste tank,

i. The separation distance requirements given in item 1 above must be restored and documented in SW11.1-WTE procedure for a transfer out of the waste tank to be designated as a supernate transfer.

ii. If the separation distance requirement is not verified or is not met, then designate transfers out of the tank as SLUDGE SLURRY TRANSFERS in the SW11.l-WTS procedure. SLUDGE SLURRY TRANSFERS must meet the requirements of the Transfer Control Program (Reference 16). Additionally, for transfers that do not meet the Sludge Carryover Minimization Program PDD separation criteria, receipt waste tanks are evaluated for entry into the Spontaneous Liberation Protection portion of the Waste Tank Quiescent Time per Flammability Control Program PDD (Reference 11).

d. If a supernate transfer is performed into a waste tank containing a sludge layer, THEN

i. Designate transfers out of the tank as SLUDGE SLURRY TRANSFERS until the separation distance requirements are demonstrated via documented engineering evaluation or rebaselining per item 1 above.

ii. An exception to this requirement can be made if an engineering evaluation is completed prior to the transfer, which demonstrates that the transfer will not disturb the sludge layer.(See Ref. 2, 21, 22, 38, and 45)

4.5 Transfers From Outside Facilities

Transfers from Outside Facilities into waste receipt tanks (e.g., Tanks 13, 22, 39 and 41) are typically numerous small batches (<10,000 gal) throughout a year. Each of these batches contains a small volume of sludge solids, and therefore, sludge level rebaselining after each transfer would be ineffective. To protect the transfer accident basis for inhalation dose, the transfers from these facilities must be considered a SLUDGE SLURRY TRANSFER if the potential inhalation dose rate is greater than the Bounding Supernate dose established in the DSA. Designation as SLUDGE SLURRY TRANSFER is important in order to provide the proper flushing requirements provided by the Transfer Control Program (Reference 16). However, over extended period of operation, solids build up. The largest contributor of influent sludge solids is H Canyon where, historically, the Tank Farms have received as much as 150,000 gallons of waste per year. Based on this rate, a detectable solids increase of 2 inches could occur in less than 3 months. The rate of solids accumulation has increased from a few fractions of an inch a year during the 1997-1999 canyon campaigns to 7 to 9 inches a year during the campaigns of 2000-2008. However, since 2008 to present, canyon receipts to Tank 39 have been decreased significantly due to process changes and separation of LLW stream to Tank 50. Average solids accumulation from January 2011 through January 2014 in Tank 39 was decreased to less than 3 inches per year. Since October 2014 to February 2016, Canyon sent only 40,000 gallons which is much less than anticipated. Projected canyon receipts for the next few years will be in the same range of present volumes. Therefore, turbidity reading shall be taken only prior to transfer out of Tank 39 to verify its separation distance requirements for supernate transfer.

In March 2013, it was recognized that DWPF recycle receipts to Tank 22 contained more solids than previously anticipated (reference 40). In addition, DWPF WCP has been revised to eliminate the solids limit. However, a conservatively estimated value of 200 gallons per batch is assumed for heat load calculations (reference 43). Actual solids sent will be verified by sampling by DWPF and adjusted accordingly (see reference 43) in WCS database. From December of 2013 to August 2017, there were 432 DWPF recycle transfers received into Tanks 13, 22 and 41 with an average actual sludge solids volume of 38 gallons per transfer (Reference 44). In addition, Tank 22 turbidity reading from South West Riser is increased only one inch from 6.28 to 7.28 inches (Reference 34) during this period after the solids removal. Therefore, Tank 22 sludge measurement frequency can be changed to semi-annually to verify separation distance requirements.

Since the fourth quarter of 2013, DWPF recycle receipts are being taken into Tank 41 or Tank 13 as needed due to Tank 22 solids removal preparation. No DWPF recycle transfers were received into either Tank 13 or Tank 41 since July 2014. Requirements for waste tank transfers into and out of these tanks are covered under the previous subsection (4.4).

Heat Loads from the receipt of solids from outside facilities are considered separately in WCS PDD.

1. Requirement: Transfers from Outside Facilities (e.g., H Canyon, DWPF) must be designated as a SLUDGE SLURRY TRANSFER unless the inhalation dose potential of the waste stream is less than the bounding supernate limit (9.8 E+07 rem/gal, Reference 37).

   a. The inhalation dose and transfer designations are documented in the Tank Farm Waste Acceptance Criteria (WAC).

   b. Rebaseline sludge level in Tanks 13, 22 and Tank 41 semi-annually when they are actively receiving the DWPF recycle transfers. Verify the separation distance between sludge level and the transfer device and document in the SW 11.1-WTE procedure.

      i. If the sludge level determination was conducted in the same tank quadrant as the transfer device riser, THEN verify the separation distance is greater than or equal to 24 inches.

      ii. If the sludge level determination was conducted from another location in the tank; THEN verify the separation distance is greater than or equal to 36 inches. or provide an engineering evaluation to show that the sludge entrainment is less than 1 wt% to consider as a supernate transfer.

      iii. If the separation distance requirement is not met, then designate transfers out of the waste tank as SLUDGE SLURRY TRANSFERS. SLUDGE SLURRY TRANSFERS must meet the requirements of the Transfer Control Program (Reference 16).

5.0 REFERENCES

1. S-TSR-G-00001, "Concentrated Storage, and Transfer Facilities Technical Safety Requirements".

2. Britt, T. E., *"*Estimated Impact of a Liquid Addition to Tank 26F through a Side-Wall Penetration*",* G-ESR-H-00099.

3. WSRC-TR-2002-00327, "CSTF Corrosion Control Program PDD".

4. WSRC-SA-2002-00007, "Concentrated Storage, and Transfer Facilities Documented Safety Analysis".

5. D149796, Inlet Deflector.

6. U-DSA-H-00003, "Concentration, Storage, and Transfer Facilities Documented Safety Analysis Addendum: Operation of 242-25H Evaporator with Leak Sites", April 2018

7. Dimenna, R.A., Eductor Placement for Tank 38 and Tank 43, M-CLC-H-02230.

8. Sudduth, Christie,"Sampling Methodology for CSTF DSA Administrative Programs", X-ESR-H-00052.

9. Dimenna, R.A. and Lee, S.Y., Flow Characteristics from Tank 43H Inlet Downcomer, SRT-EMS-2001-00009.

10. Hobbs, D.T., Final Report: Analysis of Tank 41H Saltcake Sample #2 and Comparison to Sample #1, WSRC-TR-94-0057.

11. Hilary Bui, "CSTF Flammability Control Program", WSRC-TR-2003-00087.

12. Hilary Bui, CSTF Evaporator Feed Qualification Program, WSRC-TR-2003-00055.

13. Deleted.

14. Martino, C. J., Analysis of Tank 43H Suspended Solids Sample and Sludge Level Meter Testing, WSRC-TR-2005-00161.

15. M-M6-H-8343, H Area New Hill Tanks 42 and 43 Evaporator System, Piping Diagram Process and Instruments (U).

16. Pasala, N. R., "Tank Farm Transfer Control Program, Pump Tank Transfer Jet Control Program, Waste Tank Chemical Cleaning Program", WSRC-TR-2002-00403.

17. P-PJ-H-8054, SRS 200 Area Bldg 241H Tank 32 Downcomer Replacement.

18. P-R2-F-00018, Evaporator Tank 26 Feed Pump Injector Pump.

19. P-R2-H-00020, Evaporator Tank 43 Feed Pump Injector pump.
20. Swingle, R.F., Characterization of the Tank 38H Variable Depth and Core Samples, WSRC-RP-2001-00574.

21. Deleted.

22. Tamburello, D.A.; Dimenna, R.A.; and Lee, S.Y., Tank 32 Evaporator Feed Pump Transfer Analysis, SRNL-TR-2008-00324.

23. W2010550, "Replacement High Level Waste Evaporator, Tank 32 Riser C2 - Y332-1300-20 Feed Pump, Sheet 1".

24. Deleted.

25. W701126, "Tank Plan Above 287.0' Tk. 26 PPG.-Equipment".

26. P-DCP-F-14002, "Dismantle & Remove Evaporator Feed Pumps From Tank 26 Risers R1 & R2".

27. M-DCP-F-14003,"Tank 26, C1 Riser, D&R Transfer Jet and STP Installation".

28. W704785, "Additional Waste Storage Tanks Dimensional Record As Built TK 43 Steel".

29. Deleted.

30. Deleted.

31. Deleted.

32. Deleted.

33. Deleted.

34. SW11.1-WTE-7.2, Transfer Jet/Pump/Waste Downcomer Levels and Adjustments Data Sheet.

35. Deleted.

36. Deleted

37. X-CLC-G-00014, "HLW CST Safety Analysis Radiological Source Terms".

38. Britt, T. E., "Minimum Liquid Level in Tank 43 during Simultaneous Sidewall Additions and 2H Evaporation Operation", X-ESR-H-00341.

39. Deleted.

40. Deleted.

41. X-ESR-H-00541, "DWPF Recycle Management Strategy".

42. X-ESR-F-00171, "242-16F (2F) 2013 Layup Plan and Path Forward".

43. X-SD-G-00005, "Waste Compliance Plan for Radioactive Liquid Waste Transfers from the DWPF to 241-H Tank Farm".

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46. Barrowclough, Eric, "Determination of the Amount of Settled Sludge and Slurried Sludge for Waste Tanks at SRS", X-ESR-G-00055.

47. Vitali, J. R., "Evaluations of Inhalation Dose Potential when Separation Distance between the Jet/Pump and Sludge is Less Than 24 Inches", X-CLC-G-00090.

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Document Number: WSRC-TR-2003-00089 Revision: 12

Document Title: CSTF Sludge Carryover Minimization Program

The following checklist is required to be completed and attached to the document under review in compliance with Manual E7 and S4 procedures. This list should not be considered all inclusive. Add any additional notes or comments to the end of the checklist.

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	VERSION / FORMAT		
1	If revising an existing document, are you starting with the latest, approved version of the document obtained from SmartPlant Foundation (SPF) or DCR?	Yes	
2	Are all OSR or SPF forms properly and completely filled out and is the current approved version of the form used?	Yes	
3	Does the document format include all of the sections as described in manual E7 and S4 procedures (2.31A ,3.60, etc.)?	Yes	
4	Are all of the pages properly labeled with Document Number, Revision Number, and Sequential Page/Sheet Number?	Yes	
5	Are the Subject and Purpose clearly stated and do they meet the end-users needs?	Yes	
	REFERENCES		
6	Are all References properly documented within the document and can they be easily verified within Document Control, on-line, or within the library, etc.? If reference documents are not readily available, are they attached?	Yes	
7	Have the correct design bases documents been identified (e.g., Codes, Standards, DOE Orders, SRR Requirements, Regulatory Requirements, DSA)?	Yes	
	OPEN ITEMS / INPUT		
8	If data is transferred from other documents, calculations or sources, is this data correct and applicable?	N/A	
9	Are all inputs found in the body of the document or calculation individually listed and if the document is a calculation, numbered in the Inputs section?	N/A	
10	Is there a reference/source for each input?	N/A	
11	Do the identified references/sources fully support the inputs and does the data meet appropriate quality assurance requirements?	N/A	
12	Have the correct operational and functional requirements of the facility been properly considered?	Yes	

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	OPEN ITEMS / INPUT – continued		
13	Have appropriate operational modes and worse case scenarios been considered?	Yes	
14	Are all assumptions used to support the document individually listed and numbered in the Assumptions section?	N/A	
15	Is there a justification written for each assumption that includes a technical basis?	N/A	
16	Do the justifications adequately support the assumptions?	N/A	
17	If the document is a calculation and there are Open Items, has the calculation been statused as preliminary? Note: A Confirmed calculation cannot have Open Items.	N/A	
18	If the document is a preliminary calculation, have actions required to change the status from "preliminary" to "confirmed" been listed as "open items"?	N/A	
19	If the document has open items, is there a method identified to track them? List tracking numbers in Comments (STAR, POD item number, etc.).	N/A	
	ANALYTICAL METHODS AND COMPUTATIONS		
20	Are the analytical methods and computations clearly spelled out step-by-step?	N/A	
21	Is the analytical approach in use clearly described with justification along with alternative methods?	N/A	
22	Is the methodology consistent with the purpose and objective?	Yes	
23	Are mathematical derivations correct, including dimensional consistency of results?	N/A	
24	Have calculations been checked for errors as applicable per E7-2.31A, Sections 5.3.2.5 and 5.5.1? Where a calculation has multiple iterations of the same computation with numerous input and output values, the Verifier/Checker may select a representative sample of the total input and output values for review.	N/A	
25	Were the analysis inputs correctly incorporated into the analysis and are the outputs reasonable compared to the inputs?	N/A	
26	Is the Summary of Conclusion clearly stated? Does it meet the end-user's needs? Clearly state if results meet/do not meet the Objectives of the analysis?	Yes	
27	Are the numeric values consistent with the appropriate accuracy (significant figures) of the analysis?	Yes	
28	Are safety margins consistent with good engineering practice?	Yes	

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	SOFTWARE		
29	Is software (including spreadsheets) used? If NO, then "N/A" this section.	N/A	
30	Have computer software programs used for calculations been evaluated and properly classified for this activity using OSR form 19-337 (SWCD), per 1Q QAP 20-1 and E7-2.25? Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38. B) The SWCD (software classification document) form is a site-wide application in Lotus Notes.	N/A	
31	Is computer software used for the analysis being controlled per E7-2.31A, Section 5?	N/A	
32	Were appropriate analysis methods and computer methods used?	N/A	
33	If a computer program or model is used in the calculation, is it used within the range of validity, or is use outside the range of established validity justified?	N/A	
34	Was the software program used within any restriction, criteria or test frequency requirements in the Software Quality Assurance Plan? (SQAP) (e.g., computer operating system/platform criteria, software within testing frequency).	N/A	
35	Is the software used noted on the Calculation cover sheet and referenced appropriately in the calculation?	N/A	
36	If the calculation supports the DSA, is the software and version used on the SSIL (Safety Software Inventory List) when required? Provide explanation in Comments. Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38 B) The SSIL is updated on an annual basis so recently approved SQAPs may not be added to the SSIL until the next annual update.	N/A	
37	Are the equations shown in the calculation, including example functions where Excel spreadsheets or MathCad is used?	N/A	
38	If using general-purpose commercially available software as described in E7-2.31A, Section 5.5.1, then answer YES and describe checking method (5.5.1.2.C 1, 2, or 3) in Comments	N/A	
39	Have computer program error reports been checked for potential effect on the analysis?	N/A	

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	RESULTS / CONCLUSIONS		
40	Are the results of the document consistent with the input and assumptions?	Yes	
41	Do the results of the document affect any other technical documents?	No	
42	Do the results substantiate the conclusion?	Yes	
	APPROVALS		
43	Does the document identify the method of verification, if applicable, and does it have a signature block for the verifier/checker?	Yes	

Checker: N-RAO PASALA (Print) / N Rao Pasala (Signature) Date: 6/7/18

Item No. Cont.	Comment Continuation
	None

LW FORM

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Items 44-56 are only to be completed when Verification by Document Review is being performed. The verifier assures the technical accuracy of the document by performing administrative and mathematical checks as appropriate, and by evaluating the document against the following questions:

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
44	Were the inputs correctly selected and identified?	Yes	
45	Are the assumptions made in the performance of the design or analytical activity adequately described and reasonable?	N/A	
46	When necessary, are the assumptions identified for subsequent re-verification when the detailed design activities are completed?	N/A	
47	Were appropriate design or analytical methods and computer programs used?	N/A	
48	Were the design or analytical inputs correctly incorporated into the design, analysis or evaluation?	N/A	
49	Have engineering actions required to support risk handling strategies been verified?	N/A	
50	Is the design output reasonable compared to the design or analytical inputs?	Yes	
51	Are the necessary design inputs for interfacing organizations specified in the design documents or in supporting procedures or instructions?	Yes	
52	Have suitable materials, parts, processes, and inspection and testing criteria been specified?	N/A	
53	Have existing and potential workplace hazards been identified, evaluated, and controls incorporated for the risk to worker injury or illness?	N/A	
54	Was a review conducted to confirm that there are no interferences with other ongoing or planned modifications?	N/A	
55	Have engineering judgments been identified, technically justified, and supported?	N/A	
56	Have design optimization strategies been considered / met (e.g., appropriate tailoring of requirements, design attributes, and operating strategies)?	N/A	

Verifier: N-RAO PASALA / N Rao Pasala Date: 6/7/18
Print Signature

Item No. Cont.	Comment Continuation
	None

Savannah River Remediation

WSRC-TR-2002-00403
Rev. 28

Tank Farm Transfer Control Program, Pump Tank Transfer Jet Control Program, and Waste Tank Chemical Cleaning Program

Program Description Document

PREPARED BY:

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N. Rao Pasala, Process Safety and Regulatory Engineer / Signature Date

VERIFIED BY:

Azikiwe Hooker 7/1/2019

Azikiwe Hooker, Process Safety and Regulatory Engineer / Signature (Verification by Document Review) Date

Technical Review Number: 11Q, 1.05, CX-1

APPROVED BY:

Christine Ridgeway 7/3/19

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Helen Boyd 7/9/19

Helen Boyd, Program Review Committee Chairperson / Signature Date

T Wd for 7-3-19

John Occhipinti, Tank Farm Facility Engineering Manager / Signature Date

DBB 7-3-19

Doug Bumgardner, Tank Farm & ETP Operations Facility Manager / Signature Date

Summary of Revisions

02/03	Revision 0	Original Issue.
03/03	Revision 1	See Revision 16 for Revision Summary
06/03	Revision 2	See Revision 16 for Revision Summary
11/03	Revision 3	See Revision 16 for Revision Summary
01/04	Revision 4	See Revision 16 for Revision Summary
09/04	Revision 5	See Revision 16 for Revision Summary
12/04	Revision 6	See Revision 16 for Revision Summary
08/05	Revision 7	See Revision 16 for Revision Summary
10/06	Revision 8	See Revision 16 for Revision Summary
2/07	Revision 9	See Revision 16 for Revision Summary
12/07	Revision 10	See Revision 16 for Revision Summary
1/08	Revision 11	See Revision 16 for Revision Summary
5/08	Revision 12	See Revision 16 for Revision Summary
7/08	Revision 13	See Revision 16 for Revision Summary
9/08	Revision 14	See Revision 16 for Revision Summary
10/09	Revision 15	See Revision 16 for Revision Summary
7/10	Revision 16	See Revision 16 for Revision Summary

7/10 Revision 17: 2010 DSA annual update changes and other Clarifications:

- Section 3.7: Modified over-pressure evaluation attribute and implementation item 1 to match with DSA annual update and HLW-CRF-10007.
- Section 3.8: Revised to add the statement of not requiring flushing pipe branches off of the transfer path to match with DSA annual update.
- Section 3.13: Revised to add the statement of not requiring flushing pipe branches off of the transfer path to match with DSA annual update.
- Section 3.17: Revised to add the statement of not requiring flushing pipe branches off of the transfer path to match with DSA annual update.
- Revised Reference 15.
- Added Reference 28.

1/12 Revision 18: Authorization Agreement (AA) changes:

- Revised Section 4.3 to align with AA document (reference 9) rev 3.
- Deleted reference 27.

7/12 Revision 19: 2012 Annual DSA Update & Type I/II Waste Tanks undergoing Chemical Cleaning Process DSA and TSR changes:

- Revised Section 3.26 to align with DSA Annual Update of Section 3.4.2.9.3.
- Revised Document Title to add Waste Tank Chemical Cleaning Program.
- Revised Sections 3.1, 3.15, 3.20, and 3.28 to align with Type I/II Waste Tanks undergoing Chemical Cleaning Process DSA and TSR changes.
- Added Smart Plant Foundation (SPF) on page 17.
- Added references 29, 30 and 31.

6/14 Revision 20 General Format change per S4-ENG.36 procedure

- Added TSR 5.8.2.21 to all attributes pertaining to Transfer Control Program.
- Revised Section 4.3 to delete the option of single sound isolation valve with justification for inactive locations.
- Revised Section 5.3 to confirm to latest AA revision

11/14 Revision 21 Revised for 2014 DSA Annual Update:

- Section 4.4 is deleted to match with DSA annual update
- Section 4.20, implementation item 3 has been deleted to align with current DSA. Type IV Tank waste hydrogen generation rate requirement is deleted in Rev. 9 of the DSA
- Section 4.26, revised to add LDB Drain Cell cover requirements for Transfers in and out of Tanks 49 and 51.
- Section 4.28, annual update deleted Tanks 5 & 6 from Waste Tank Chemical Cleaning since those two Tanks are grouted.

11/15 Revision 22 Revised for 2015 DSA Annual Update:

- Section 4.1, revised to add 2 Sigma uncertainty for IDP calculations using sample results, deleted H-Area Type IV tanks from LOW REM TRANSFERS list and added to the criteria, deleted information related to MECHANICAL CLEANING MODE, in implementation section of 4.1, deleted item 3 since no FTF pump tanks are receiving outside facilities waste.
- Section 4.2, added 2 Sigma uncertainty to IDP calculations.
- Section 4.3, corrected a typo from 3.28 to 4.28.
- Section 4.13, added 2 Sigma uncertainty to flushing IDP and clarified Corrosion Control flushing requirement.
- Section 4.14, deleted the statement related to CONTENGENCY TRANSFERS in the attribute, added explanation of not needing to stop the transfer equipment for certain activities into waste tanks.
- Section 4.21, revise “during” to “prior to”

- Sections 4.22 and 4.23, revised to add 2 Sigma uncertainty for IDP calculations using sample results
- References Section, updated references 11, 15 and added reference 32.

4/16	Revision 23	Revised for Trapped Gas PISA, DSA Changes. • Revised Section 4.6 to add "prior to transfer initiation" • Revised Section 4.7 to change Overpressure evaluation to Transfer Pump Speed Evaluation and added the new criteria • Revised Section 4.9 to add "prior to transfer initiation" • Revised Section 4.14 to add a clarification that Dissolution Skid do not have a continuous make up capability • Revised Section 4.23 to clarify the implementing item
9/16	Revision 24	Revised for 2016 DSA Annual Update: • Revised Section 4.3 to clarify the "Drip-Wise" leak definition
12/17	Revision 25	Revised for 2017 DSA Annual Update and STAR items: • Section 4.3, deleted additional requirement for VBs leak check for HIGH REM WASTE TRANSFERS, revised non-waste transfer definition criteria, deleted implementation item # 2, revised implementation item # 3. (Annual Update) • Deleted reference to / mention of 242-16F evaporator throughout the document. (Annual Update) • Sections 4.26 & 4.27, deleted 15/16 VB requirements. (Annual Update) • Section 4.28, deleted the individual tank numbers and revise to say Type I & II waste tanks except Tank 1. (STAR 2017-CTS-002812, Action Item # 4)
6/18	Revision 26	Revised for 2018 DSA Addendum (Operation of the 242-25H Evaporator with Leak Sites): • Updated the following sections: 2.0, 4.20, 4.22, & 4.30.

10/18 Revision 27 Revised for 2018 Tank Closure Cesium Removal (TCCR) Unit Implementation and Star Item 2016-CTS-006619 (Action #4)

- Updated the following sections: 1.0, 2.0, 4.1, 4.2, 4.7, 4.14, 4.16, & 4.22.

6/19 Revision 28 Revised for SWPF Interface DSA Changes:

- Updated Sections to add TSR or DSA requirement numbers
- Revised Section 4.1 to change Bounding Supernate IDP to 9.7E07 rem/gal
- Revised Section 4.3 to add isolation of SWPF to Tank 50 material from HDB-7 and HDB-8
- Added Section 4.4 for Submersible Blender Pump Operation Program
- Revised Section 4.13 to add pre-transfer flush for HIGH REM TRANSFERs
- Revised Section 4.14 to remove equipment to stop siphons not requiring for transfers in and out of Tank 50
- Revised Section 4.21 to add EMD STP operations to ARM locations

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List of Acronyms and Abbreviations

AA	Authorization Agreement
AC	Administrative Control
AFD	Adjustable Frequency Drive
AIM	Asset and Information Management
ARM	Area Radiation Monitor
ASME	American Society of Mechanical Engineers
BMP	Best Management Practice
BTU	British Thermal Unit
Ci	Curie
CLI	Component Location Identification
COP	Clean Out Port
CST	Concentration, Storage, and Transfer
CSTF	Concentration, Storage, and Transfer Facilities
CTS	Contingency Transfer System
DATR	Design Authority Technical Review
DB	Diversion Box
DCS	Distributed Control System
DHEC	Department of Health and Environmental Control
DOE	Department of Energy
dpm	disintegrations per minute
DSA	Documented Safety Analysis
DWPF	Defense Waste Processing Facility
EG	Evaluation Guideline
EMD	Curtis-Wright Electro-Mechanical Division
ERD	HLW Emergency Response Data and Waste Tank Data (N-ESR-G-00001)
ESP	Extended Sludge Processing
ETAF	Electronic Transfer Approval Form
ETP	Effluent Treatment Project
FDB	F-Area Diversion Box
FFA	Federal Facilities Agreement
FPP	F-Area Pump Pit
FPT	F-Area Pump Tank
ft^3	cubic foot
FTF	F-Area Tank Farm
gal	gallon
GDL	Gravity Drain Line
gpm	gallons per minute
HDB	H-Area Diversion Box
HEPA	High-Efficiency Particulate Air
HLLCP	High Liquid-Level Conductivity Probe
HPFP	High Point Flush Pit
HPP	H-Area Pump Pit
HPT	H-Area Pump Tank

hr	hour
HTF	H-Area Tank Farm
IAL	Inter Area Line
IDP	inhalation dose potential
ITP	In-Tank Precipitation
IV	Independent Verification
kg	kilogram
L	liter
LCO	Limiting Condition for Operation
LDB	Leak Detection Box
LPS	Leak Probe Sleeve
MEL	Master Equipment List
ml	milliliter
MLDB	Modified Leak Detection Box
NCR	Non-Conformance Report
OA	Oxalic Acid
OOS	Out of Service
ORPS	Occurrence Reporting and Processing System
PAAA	Price Anderson Amendments Act
PDD	Program Description Document
PP	Pump Pit
rem	roentgen equivalent man
SAC	Specific Administrative Control
SC	Safety Class
SPF	Smart Plant Foundation
SS	Safety Significant
SBP	Submersible Blender Pump
SMP	Submersible Mixer Pump
ST	Source Term
STP	Submersible Transfer Pump
TCCR	Tank Closure Cesium Removal
TSR	Technical Safety Requirements
VB	Valve Box
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
WAC	Waste Acceptance Criteria
WCP	Waste Compliance Plan
WCS	Waste Characterization System
wt%	weight percent

1.0 PURPOSE

The purpose of this PDD is to provide background information and describe the attributes of the Concentration, Storage, and Transfer Facilities (CSTF) Transfer Control Program and Pump Tank Transfer Jet Control Program in sufficient detail such that these programs can be implemented. Also, it will document implementation details of other commitments delineated in DSA/TSR Administrative Control Programs, Federal Facilities Agreement (FFA), Wastewater Permits, Price Anderson Amendments Act (PAAA), Authorization Agreement (AA), DOE Manual 435.1-1, and Best Management Practices (BMPs) related to WASTE TRANSFERS.

Commitments taken from the DSA/TSR that are delineated in this PDD involve transfer related aspects only. Other non-transfer related commitments that may be contained within a portion of a TSR AC Program referenced within this PDD are not contained herein. An example of this is Section 4.21 for the ARM Location Program. This section only discusses commitments related to above-ground transfers and does not discuss non-transfer related requirements (e.g. SMP related requirements).

The output documents generated by this PDD shall ensure independent verification or validation of results and conclusions. Output documents include, but are not limited to, calculations, evaluations, procedures, and technical reports.

Calculations issued as output documents shall be confirmed Type 1 calculations in accordance with the requirements of the E7 Manual, Procedure 2.31. Technical Reports issued as output documents shall comply with the requirements of E7 Manual, Procedure 3.60. Assumptions and recommendations from these reports shall be addressed in either the Design Authority Technical Review (DATR), waste transfer approval procedures, or other evaluations performed against the proposed WASTE TRANSFER.

The functional classification of a calculation issued as an output document in support of implementation items contained in this PDD shall be in accordance with the level of control as dictated in DSA Chapter 3 (either SS or SC).

Engineering evaluations issued as output documents shall be confirmed Type 2 calculations in accordance with the requirements of the E7 Manual, Procedure 2.31. These engineering evaluations may also be issued to the Document Control Center as drawings for retrievability in accordance with E7 Manual, Procedure 2.30.

Samples required in this document shall follow the methodology described in Reference 11.

Given the limited applicability of the Transfer Control Program attributes to CONTINGENCY TRANSFERS and TCCR TRANSFERS, those attributes which are required by the DSA/TSR will be directly noted in each attribute section. Where CONTINGENCY TRANSFER and TCCR TRANSFER is not specifically noted, it shall be understood that the attribute does not apply.

1.1 PDD Owner Qualifications:

The qualifications for PDD ownership are established in S-4 Manual Procedure Eng-36.

1.2 PDD Owner Responsibilities:

The PDD Owner Responsibilities are established in S-4 Manual Procedure Eng-36.

2.0 SCOPE

The scope of this Program Description Document (PDD) is to provide guidance to engineering and operational personnel for implementing transfer related controls contained in the Documented Safety Analysis (DSA) programs and Technical Safety Requirements (TSR) Administrative Controls (ACs) in transfer procedures, transfer evaluations and approval (ETAF) procedures. This document is not a Safety Basis document.

Revision 27 of this PDD supports changes associated with the TCCR Unit System Implementation and Star Item 2016-CTS-006619 (Action #4) .

3.0 BACKGROUND

3.1 Safety Function

The safety function of CSTF Transfer Control Program is to protect bounding conditions or serve as a first level of control within the accident analyses. Several transfer related requirements from other TSR Admin. Control programs are also included in this PDD.

4.0 PROGRAM DESCRIPTION

INPUTS, KEY ATTRIBUTES, EVALUATIONS, CRITERIA AND OUTPUTS ARE LISTED IN THE FOLLOWING SUB-SECTIONS FOR EACH REQUIREMENT.

4.1 TRANSFER TYPE (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.a

Prior to TRANSFER INITIATION a determination of the type of transfer shall be performed. This evaluation will distinguish between HIGH-REM WASTE TRANSFERS, LOW-REM WASTE TRANSFERS, CHEMICAL CLEANING TRANSFERS, ESP SLUDGE SLURRY transfers, and SLUDGE SLURRY TRANSFERS for all planned transfers.

DSA Chapter 3 “Hazard and Accident Analyses” used several waste streams to signify the material at risk on a per unit volume basis. For inhalation dose potential requirements, an analytical uncertainty of 2 Sigma shall be included when sample results are used. Some exceptions are described in DSA Section 5.3 and these exceptions are identified in this document as needed. For inhalation dose potential limit verifications, if a specific uncertainty is not included with the sample results (for use of the 2 Sigma application), then a generic conservative analytical uncertainty may be used as described in Reference 32. Reference 32 allows the use of 27% uncertainty for Sludge Slurry IDP calculations and 100% uncertainty for Supernate IDP calculations if no sample results uncertainty is available. When comparing to the IDP limits, the conservative uncertainty values can be used to lower the limit instead of calculating the IDP with uncertainty.

IDP uncertainty can be calculated based on isotopic concentration measurement uncertainty only since uncertainties associated with physical property data (e.g. mass, density) are very small in comparison to isotopic concentration uncertainties and can be ignored without significant impact on the overall uncertainty (reference 32). Also, analytical uncertainty would not be applicable for concentrations reported at Minimum Detectable Levels (MDL), as there is at least a 95% confidence that the result is below this value.

HIGH-REM WASTE TRANSFERS have an inhalation dose potential (including 2 Sigma uncertainty) of greater than 2.0E+08 rem/gal. IDP calculations for HIGH/ LOW REM transfer types will be performed outside the WCS. Therefore, uncertainty will be included in the calculations and WCS limits will not be changed.

CHEMICAL CLEANING TRANSFERS are WASTE TRANSFERS containing Oxalic Acid (OA) with IDP less than or equal to 9.8E+07 rem/gal and will be categorized separately from HIGH-REM and LOW-REM WASTE TRANSFERS. Values used within this program represent broad chemistry regimes related to applicability of test data to DSA assumptions. These values do not represent thresholds over which a specific limit is crossed. Thus, these values do not need to include analytical uncertainty.

LOW-REM WASTE TRANSFERS have an inhalation dose potential of less than or equal to 2.0E+08 rem/gal. If limits are met by programs (or their defining aspects) and do not require sample results, then analytical uncertainty is not applicable. The following may be categorized as LOW-REM WASTE TRANSFERS:

- Transfers out of H-Area waste tanks that implement TSR Administrative Control 5.8.2.19 (Sludge Carryover Minimization Program) No uncertainty required.

- Transfers of evaporator bottoms. No uncertainty required.

- F-Area transfers (restricted to less than or equal to 16.7 wt% sludge solids or have an inhalation does potential that meets the LOW-REM WASTE TRANSFER criteria [as determined by engineering evaluation]). No uncertainty required.

SLUDGE SLURRY TRANSFERS out of Waste Tanks 33 and 34 when the suction of the transfer device (pump or jet) is below the sludge layer shall be verified by sampling to have an inhalation dose potential (including 2 Sigma uncertainty) of less than or equal to 2.0E+08 rem/gal prior to the transfer. IDP calculations for HIGH/ LOW REM transfer types will be performed outside the WCS. Therefore, uncertainty will be included in the calculations and WCS limits will not be changed.

- Transfers out of waste tanks (including Tanks 33 and 34) that do not comply with Administrative Control 5.8.2.19 but the suction of the transfer device (pump or jet) is at or above the sludge layer. No uncertainty required.

Transfers from other facilities which have been shown to be less than or equal to 2.0E+08 rem/gal (including 2 Sigma uncertainty) by their Waste Compliance Plan (WCP). IDP calculations for HIGH/ LOW REM transfer types will be performed outside the WCS. Therefore, uncertainty will be included in the calculations and WCS limits will not be changed.

CSTF initiated transfers that have been verified by sampling to have an inhalation dose potential (including 2 Sigma uncertainty) of less than or equal to 2.0E+08 rem/gal. IDP calculations for HIGH/ LOW REM transfer types will be performed outside the WCS. Therefore, uncertainty will be included in the calculations and WCS limits will not be changed.

ESP SLUDGE SLURRY is a type of WASTE TRANSFER material distinguished by its radiolytic hydrogen generation rate. The radiolytic hydrogen generation rate of ESP SLUDGE SLURRY is greater than 1.5E-5 ft^3/gal-hr and less than or equal to 5.0E-5 ft^3/gal-hr. Waste that is being transferred with a radiolytic hydrogen generation rate greater than1.5E-5 ft^3/gal-hr must be classified as ESP SLUDG ESLURRY. Classification of material as ESP SLUDGE SLURRY is independent of the inhalation dose potential of the material and is independent of the waste tank containing the material being classified as an ESP SLUDGE SLURRY WASTE TANK. No uncertainty required.

A SLUDGE SLURRY TRANSFER is a WASTE TRANSFER that does not comply with the Sludge Carryover Minimization Program (Administrative Control 5.8.2.19). No uncertainty required.

Accident Analyses are performed for various types of transfers and controls are established based on the type of WASTE TRANSFER. Therefore, it is important to determine the type of WASTE TRANSFER prior to implementing the applicable controls.

Definitions of TCCR TRANSFERS and CONTINGENCY TRANSFERS given below for completeness; however, this attribute is not applicable to these transfers.

A TCCR TRANSFER is a transfer of waste to/from the TCCR Unit or transfer of waste originating from the primary side of Tank 10. TCCR TRANSFERS are considered WASTE TRANSFERS but are categorized separately from “HIGH-REM” or “LOW-REM” waste transfers. TCCR TRANSFERS have an inhalation dose potential of less than or equal to 1.4E+06 rem/gal (Tank 10 TCCR Feed Stream) or less than or equal to 2.1E+06 rem/gal (Tank 10 TCCR Sludge Slurry Stream).

CONTINGENCY TRANSFERS are transfers with an IDP less than Bounding Supernate (See DSA Section 3.4.2.12.3); therefore, waste transfer requirements for HIGH-REM WASTE TRANSFERS and sludge-slurry waste do not apply to CONTINGENCY TRANSFERS. Transfers with inhalation dose potential greater than 9.7E+07 rem/gal (Bounding Supernate) cannot be performed as CONTINGENCY TRANSFERS. Excluding waste tanks in ACIDIC CHEMICAL CLEANING MODE, Bounding Supernate is assumed to leak into the annulus (see DSA Section 3.4.2.12) and Contingency Transfers are assumed to be less than or equal to 9.7+07 rem/gal. Therefore, no samples are required for these waste tanks and analytical uncertainty does not apply.

CONTINGENCY TRANSFERS initiated from the annulus of a tank in ACIDIC AND NON-ACIDIC CHEMICAL CLEANING MODES, are permitted provided it has been shown that the inhalation dose potential (IDP) of the chemical cleaning slurry which has leaked to the annulus is less than or equal to 9.7E+07 rem/gal (including 2 Sigma uncertainty). If limits are met by programs (or their defining aspects) and do not require sample results, then analytical uncertainty is not applicable. In addition, the Transfer Control Program and Waste Tank Chemical Cleaning Program Requirements (5.8.2.21.g.

and 5.8.2.53) for these CHEMICAL CLEANING TRANSFERS do not apply based on the following.

- Flushing is not required due to self-draining design feature.
- The TRANSFER PATH associated with the CONTINGENCY TRANSFER is a dedicated path (hose-in-hose) from the annulus back to the primary tank bypassing the facility transferring network (e.g., valve boxes, diversion boxes, pump tanks).
- Because the transfer involves a PROCESS AREA (i.e., tank and annulus) in ACIDIC CHEMICAL CLEANING MODE which has been analyzed by the DSA to contain acidic waste, neutralization of the acidic waste is not required in the annulus prior to transfer or in the primary tank upon receipt.

IMPLEMENTATION:

Reference 7 documented that all F-Area Tanks (supernate and sludge slurry with 16.7 wt% sludge solids concentration) with the exception of Tank 34 have inhalation dose potentials less than 2.0E+08 rem/gal. For Tank 34 the required sludge concentration to reach 2.0E+08 rem/gal is 10 wt. % due to Am-241 process in F-Canyon between 1984 and 1989. There was some uncertainty that Am-241 may have been sent to Tank 33 during that time. Therefore, SLUDGE SLURRY TRANSFERS out of Tanks 33 and 34 are required to be verified less than 2.0E+08 rem/gal by sampling. All transfers out of F-Area Tanks are classified as LOW-REM WASTE TRANSFERS along with SLUDGE SLURRY TRANSFER verification requirements in Section 3.2.

CHEMICAL CLEANING TRANSFERS are limited to transfers originated from Type I/II Waste Tanks and are categorized separately from HIGH-REM and LOW-REM WASTE TRANSFERS. Except for CONTINGENCY TRANSFERS from the annulus of a Chemical Cleaning waste tank, CHEMICAL CLEANING TRANSFERS, by definition, have an IDP ≤ 9.8E+07 rem/gal. This value is defined in the DSA by a bounding analysis and requires no verification. Chemical Cleaning Mode entry requirement of ≤ 10,000 gallons of sludge protects the assumption of this bounding analysis.

DSA Section 3.4.2.12.3 assumption states that excluding Type I/II waste tanks undergoing chemical cleaning, only Bounding Supernate (IDP ≤ 9.7E+07 rem/gal) leaks from the tank into the annulus through the wall cracks. Bounding Sludge Slurry or ESP Sludge Slurry does not leak from the tank into the annulus. Therefore, IDP verification is not required for CONTINGENCY TRANSFERS except for Type I/II Waste Tanks undergoing chemical cleaning.

In NON-ACIDIC CHEMICAL CLEANING MODE, only WASTE TRANSFERS are permitted out of the treatment Waste Tank.

All H-Area Tank supernate transfers that comply with the Sludge Carryover Minimization Program can be categorized as LOW-REM WASTE TRANSFERS. SLUDGE SLURRY

TRANSFERS out of H-Area waste tanks and F-Area tanks 33 and 34 that do not meet the Sludge Carryover Minimization Program (e.g., minimum separation distance) but the suction of the transfer device (pump or jet) is at or above the sludge layer can be categorized as LOW-REM WASTE TRANSFERS. SLUDGE SLURRY TRANSFERS for these tanks with the transfer device (pump or jet) below the sludge layer shall be verified by sampling, ensuring that the inhalation dose potential (including 2 Sigma uncertainty) is less than or equal to 2.0E+08 rem/gal to be categorized as LOW-REM WASTE TRANSFERS. Sampling is required after each batch of slurrying of the settled sludge. Sampling methodology described in Reference 11 shall be followed. The inhalation dose potential can be evaluated using one of the following sample analysis options:

1. Gross α sample analysis result less than 0.2247 Ci/L. This value was derived in Reference 25 based on the bounding β value (from Bounding Sludge Slurry) and bounding γ value (from Bounding Supernate),

2. Sample wt% sludge solids + Sample analysis for the isotopes listed in the DSA input

3. Sample wt% sludge solids + Bounding Sludge Slurry inhalation dose potential

If the Waste Characterization System (WCS) reflects a sampled sludge slurry isotopic analysis results for these tanks, then WCS information is acceptable to use for categorizing as LOW-REM WASTE TRANSFERS.

In general, pump tanks are used as intermediate waste transfer facilities for transfers within the Tank Farms, between F and H Tank Farms and receipt from outside facilities. Influents to the pump tanks from outside facilities will be controlled through Waste Acceptance Criteria (WAC) and Waste Compliance Plan (WCP). If a pump tank receives a HIGH-REM WASTE TRANSFER waste stream, transfers out of or through the pump tank shall be considered as a HIGH-REM WASTE TRANSFER until the pump tank is pumped down to the heel. During transfers through a pump tank, the inhalation dose potential of the waste stream leaving the pump tank is assumed to be the same as the inhalation dose potential of the material entering the pump tank (i.e., a LOW-REM WASTE TRANSFER to a pump tank would be considered a LOW-REM WASTE TRANSFER after leaving the pump tank). Refer to DSA Section 3.4.1.5.2 for details.

If actions are taken to mobilize the solids heel in a pump tank (installation of a new pump tank agitator or other pump tank equipment does not necessarily result in mechanical agitation of the solids in the heel), the initial transfer through the pump tank shall be considered a HIGH-REM WASTE TRANSFER after leaving the pump tank regardless of the inhalation dose potential of the waste stream entering the pump tank, due to the presence of newly mobilized solids (unless the waste stream is confirmed not to be a HIGH-REM WASTE TRANSFER via sampling).

Current facility configuration assumptions of F-Area Tank Farm preclude a HIGH-REM WASTE TRANSFER from being initiated within F-Area Tank Farm. Facility modifications that could challenge these configuration assumptions (e.g., installing a new agitator in FPT-3) are required to be evaluated by the USQ process per Manual 11Q, Procedure 1.05, which would ensure that a HIGH-REM WASTE TRANSFER in F-Area Tank Farm does not occur without

proper safety basis changes and DOE approval. Normally sumps collect the groundwater and rainwater in-leakage. Typically, these sumps will be emptied into a pump tank or a waste tank and the transfer will be considered as a WASTE TRANSFER (LOW-REM or HIGH-REM WASTE TRANSFER) unless the contents can be classified as a non-waste transfer as explained below.

Transfers from secondary containment sumps are considered to be WASTE TRANSFERS unless the sump contents can be demonstrated to meet the following non-waste transfer criteria described in DSA Section 3.4.1.5.1:

- Transfer stream has a sufficiently low (orders of magnitude) inhalation dose potential (≤ 2.5E+05 rem/gal) such that hazards (e.g., spills, explosions) posed by the stream could not challenge the EGs.

- Hazards (e.g., spills, explosions) posed by the transfer stream will not release an amount of material that could challenge the chemical EGs, as defined in Reference 33. The amount of material released is determined from the use of the five-factor ST approach (see DSA Section 3.4.1.1)

Reference 34 evaluated chemical consequence associated with waste streams which are sufficiently low IDP <2.5E+05 rem/gal (non-waste transfers). It concluded that the worst case scenario yields a ST (<8.9 gallons) that does not challenge the Onsite chemical EGs as defined in Reference 33. Therefore, it bounds all other non-waste transfers and no additional evaluation for chemical consequences is needed as long as it meets Reference 34 requirements.

Reference 16 evaluated HPP-4 sump sample results of total alpha = 4.83E+03 dpm/ml and total beta/gamma = 8.69E+05 dpm/ml and material at risk of 15,000 gallons for non-waste transfer criteria and concluded that consequences for this material would be approximately 5 orders of magnitude less than the consequences reported in the DSA. Therefore, any sample results less than total alpha = 4.83E+03 dpm/ml, total beta/gamma = 8.69E+05 dpm/ml and material volume less than 15,000 gallons can be considered as a non-waste transfer. Since these determinations are based on orders of magnitude, analytical uncertainty does not apply.

If the inhalation dose potential for the proposed transfer exceeds the above evaluated sample results, further evaluation of the sample can be performed to determine if the transfer can be classified as a non-waste transfer. The sample analysis can be compared to the applicable worst-case accident scenario described in the CSTF DSA for the inhalation dose potential, material at risk, and unmitigated onsite consequences for the transfer. To qualify the transfer as a non-waste transfer, the consequence analysis for the proposed transfer can be based on current realistic (less conservative) inputs/variables as compared to the inputs used in the accident analysis documented in the CSTF DSA. For example, the analysis can consider both the limited material at risk due to the smaller volume (limited by the size of the sump), and curie content of the transfer (typically slightly contaminated groundwater and rainwater). If the projected consequences are significantly less than the DSA consequences, the transfer is not considered a WASTE TRANSFER. If no samples are analyzed, or the sample analysis consequences when evaluated against the worst-case accident scenario documented in the DSA are not significantly

lower than the DSA consequences, the contents shall be transferred either as a LOW-REM WASTE TRANSFER or HIGH-REM WASTE TRANSFER as explained below.

Sump transfers where the affected sump is considered a LEAK DETECTION LOCATION for a HIGH-REM WASTE TRANSFER shall be considered a HIGH-REM WASTE TRANSFER under the following conditions:

1. Sump transfer is required while the HIGH-REM WASTE TRANSFER procedure is open, regardless of actual sump level.

2. Sump transfer is required after the HIGH-REM WASTE TRANSFER procedure is closed and the affected sump level exceeded the TSR LCO level limit (e.g., LCO 3.7.1, 3.7.2) while the HIGH-REM WASTE TRANSFER procedure was open.

Once the HIGH-REM WASTE TRANSFER procedure is closed, if the sump contents are sampled and verified to have an inhalation dose potential of less or equal to 2.0E+08 rem/gal, the sump transfer can be considered as a LOW-REM WASTE TRANSFER. Additionally, if the affected sump level has been reduced below the TSR LCO level limit (with the HIGH-REM WASTE TRANSFER procedure closed), the subsequent sump transfer can be considered as a LOW-REM WASTE TRANSFER.

All other sump transfers, other than previously described, can be considered a LOW-REM WASTE TRANSFER.

The inhalation dose potential for Evaporator Bottoms in all three evaporators is always lower than the 2.0E+08 rem/gal waste stream limit (LOW-REM WASTE TRANSFER). Based on this, Evaporator transfer operations will be always considered as LOW-REM WASTE TRANSFERS and no verification is required.

Per DSA Section 3.4.2.17, consequences from the release of evaporator overheads tanks contents are judged to be negligible and no controls are required. Therefore, overheads are not considered as WASTE TRANSFERS.

<u>Implementation Items</u>:

1. Prior to TRANSFER INITIATION, determine the transfer type (HIGH-REM, LOW-REM, CHEMICAL CLEANING, ESP SLUDGE SLURRY, or SLUDGE SLURRY) for waste tank to waste tank transfers using WCS, sample results (as required), transfer device suction location and Sludge Carryover Minimization Program requirements. Document the results in the transfer procedure during the procedure development and waste transfer evaluation and approval procedure prior to the transfer. For inhalation dose potential requirements an analytical uncertainty of 2 Sigma shall be included when sample results are used.

2. Verify the transfer type documented in the waste tank to waste tank transfer procedure is valid using the waste transfer evaluation and approval procedure prior to the transfer.

3. Deleted

4. Verify that the waste stream from outside facilities is approved per the ERD (Reference 20) prior to the transfer.

5. Normally the inhalation dose potential from outside facilities into HTF pump tanks is less than or equal to 2.0E+08 rem/gal (LOW-REM WASTE TRANSFER) through the WAC/WCP. If the inhalation dose potential is greater than 2.0E+08 rem/gal (HIGH-REM WASTE TRANSFER) for H-Area pump tanks (i.e., the pump tank was in the TRANSFER PATH of a HIGH-REM WASTE TRANSFER), transfer out of or through these pump tanks shall be considered as a HIGH-REM WASTE TRANSFER until it is pumped down to the heel. LOW-REM WASTE TRANSFER procedures from these pump tanks shall verify that no HIGH-REM WASTE TRANSFER waste stream has been received into the pump tank that would cause the transfer from the pump tank to be considered as a HIGH-REM WASTE TRANSFER.

6. Transfers from sumps that are considered as LEAK DETECTION LOCATIONS for HIGH-REM WASTE TRANSFERS (based on the previously discussed criteria) shall be designated as HIGH-REM WASTE TRANSFERS. Transfers from sumps that are considered LEAK DETECTION LOCATIONS in support of maximum missing waste shall be designated as a LOW-REM WASTE TRANSFER or a non-waste transfer based on the previously discussed criteria.

7. SLUDGE SLURRY TRANSFERS initiated in H-Area waste tanks and F-Area tanks 33 and 34 where the suction of the transfer device (pump or jet) is below the sludge layer, must be verified by sampling to categorize the transfer as a LOW-REM WASTE TRANSFER. The inhalation dose potential (including 2 Sigma uncertainty) can be evaluated using one of the sampling analysis methods described in the implementation section and it shall be less than or equal to 2.0E+08 rem/gal to categorize them as LOW-REM WASTE TRANSFERS.

8. Prior to the transfer, verify the applicable crane booms are controlled per Reference 13.

9. The first transfer immediately after actions are taken to mobilize the solids heel in a pump tank shall be considered a HIGH-REM WASTE TRANSFER after leaving the pump tank regardless of the inhalation dose potential of the waste stream entering the pump tank unless the waste stream is confirmed not to be HIGH-REM WASTE TRANSFER via sampling.

10. Prior to use of CTS for a chemical cleaning slurry, IDP shall be verified by sampling or engineering evaluation to be less than or equal to 9.7E+07 rem/gal. For inhalation dose potential requirements an analytical uncertainty of 2 Sigma shall be included when sample results are used.

4.2 F-AREA TANK FARM SLUDGE SLURRY TRANSFERS (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.a,b

F-Area Tank Farm SLUDGE SLURRY TRANSFERS shall be less than or equal to 16.7 wt% sludge solids or have an inhalation dose potential that meets the LOW-REM WASTE TRANSFER criteria [as determined by engineering evaluation]. SLUDGE SLURRY TRANSFERS out of Tanks 33 and 34 when the suction of the transfer device (pump or jet) is below the sludge layer shall be verified by sampling to meet the LOW-REM WASTE TRANSFER criteria.

IMPLEMENTATION:

When SLUDGE SLURRY TRANSFERS are planned for all F-Area Tank Farm Tanks except Tanks 33 and 34, sludge slurry wt% solids shall be verified to be less than or equal to 16.7 wt% or verify that it meets the LOW-REM WASTE TRANSFER dose potential criteria by engineering evaluation. The verification can be based on either sample results after the slurrying prior to the transfer or calculations using the information in WCS. For SLUDGE SLURRY TRANSFERS, out of Tanks 33 and 34, when the suction of the transfer device (pump or jet) is below the sludge layer, the inhalation dose potential shall be verified to be less than or equal to 2.0E+08 rem/gal, by sampling. The inhalation dose potential of 2.0E+08 rem/gal was calculated for 10 wt% slurry of Tank 34 material when the large quantity of Am-241 from the Rocky Flats Scrub Alloy campaigns was included (Reference 7). The large quantity of Am-241 contributed about 90% of the sludge slurry dose for the Tank 34 material. The Am-241 from Rocky Flats materials were derived based on accountability records, which have great accuracy and are not subject to much error. In addition, about 95% of the Rocky Flats scrub alloy material was attributed to Tank 34 which has a smaller sludge mass than Tank 33. Therefore, a reasonable limit to apply to Tank 34 during slurrying operations would be 8 wt% sludge solids in order to ensure 2.0E+08 rem/gal is not exceeded. Since the amount of sludge in Tank 33 is more than twice the amount of sludge in Tank 34, a sludge slurry with 16 wt% sludge solids from Tank 33 would provide significant margin to prevent exceeding 2.0E+08 rem/gal even if all the Am-241 from the Rocky Flats scrub alloy material were received into Tank 33 instead of Tank 34. The sample shall be performed after initial slurrying of the sludge inventory to be transferred. The results will be documented in an engineering evaluation.

IDP uncertainty can be calculated based on isotopic concentration measurement uncertainty only since uncertainties associated with physical property data (e.g. mass, density) are very small in comparison to isotopic concentration uncertainties and can be ignored without significant impact on the overall uncertainty (reference 32). Also analytical uncertainty would not be applicable for concentrations reported at Minimum Detectable Levels (MDL), as there is at least a 95% confidence that the result is below this value.

Implementation Items:

1. Verify that F-Area Tank Farm SLUDGE SLURRY TRANSFERS out of all Tanks except 33 and 34 are less than or equal to 16.7 wt% sludge solids or an engineering evaluation has been performed to determine the inhalation dose potential that meets the LOW-REM WASTE TRANSFER criteria prior to the transfer.

2. When the suction of the transfer device (pump or jet) is below the sludge layer, verify that SLUDGE SLURRY TRANSFERS out of Tanks 33 and 34 have inhalation dose potential (including 2 Sigma uncertainty) less than or equal to 2.0E+08 rem/gal by limiting sludge slurry solids wt% less than or equal to 16 and 8 wt% by sample respectively or by radiological sample analysis prior to the transfer.

4.3 TRANSFER PATH (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.a,q,r

Prior to TRANSFER INITIATION, a determination of the TRANSFER PATH shall be performed. Implementing procedures shall address identification of sound isolation points as part of TRANSFER PATH determination. This evaluation shall identify the necessary PROCESS AREA(S) and LEAK DETECTION LOCATIONS needed to support the transfer. This evaluation will also ensure the transfer line segments associated with the TRANSFER PATH and piping downstream of the isolation point (excluding segments designated as Out-of-Service) has acceptable integrity prior to initiating the transfer. For CHEMICAL CLEANING TRANSFERS, the evaluation shall also include requirements provided as part of Section 4.28.

Prior to TRANSFER INITIATION through HDB-7, isolation (single leak-tested valve, double valve isolation, blank, or jumper removal) shall be established in HDB-7 to preclude waste from entering the Tank 50 Valve Box except during intended transfers from HDB-7 through the Tank 50 Valve Box.

Prior to TRANSFER INITIATION from Tank 50, isolation (single leak-tested valve, double valve isolation, or blank) shall be established in the Tank 50 Valve Box to preclude Tank 50 material from entering HDB-7 and HDB-8 [via the Effluent Treatment Project (ETP) DB].

Prior to TRANSFER INTIATION from Salt Waste Processing Facility (SWPF) To Tank 50, isolation (single leak-tested valve, double valve isolation or blank) shall be established in the Tank 50 Valve Box to preclude SWPF material from entering HDB-7 and HDB-8 (via ETP DB).

> TRANSFER PATHS are established for the planned movement of waste through the transfer system (excluding the venting and draining of transfer lines associated with a LOW-REM WASTE TRANSFER where there is no potential to siphon waste). The TRANSFER PATH is defined as a combination of the transfer lines whose primary containment constitutes a continuous liquid transfer flow path. The TRANSFER PATH begins at the plane where the transfer line exits primary containment (e.g., the waste tank / pump tank / evaporator pot wall) or at the jet for sump transfers. The TRANSFER PATH ends at the plane where the transfer line enters primary containment (e.g., the waste tank / pump tank / evaporator pot wall).
>
> Waste tank primary containment includes tank risers sufficiently open to the waste tank such that they do not have the potential for pluggage and overflow. The TRANSFER PATH includes all piping branches up to the first sound isolation point (e.g., closed valve, blank, dummy Hanford connector, evaporator clean out port [COP] blanks). Transfer lines that are not Out-of-Service are assumed to maintain their primary containment function up to an acceptable waste location (e.g., waste tank, pump tank). As an example, a diversion box downstream of the first sound isolation point of the TRANSFER PATH is not considered a LEAK DETECTION LOCATION for the TRANSFER PATH.

It is recognized that jumpers and connectors within secondary containments (e.g., valve boxes, diversion boxes, and tank risers) may experience minor leakage. As discussed in DSA Chapter 4, transfer line jumpers and connectors along a TRANSFER PATH are permitted to have "drip-wise" leakage. "Drip-wise" leakage shall not be a continuous flow of material or spray. "Drip-wise" leakage shall not exceed the initial (i.e., residual) waste volumes presented in DSA Chapter 3 within a 30-day period. "Drip-wise" leak can be determined as follows:

1. Determine the allowable leak volume using the residual waste volume of the LEAK DETECTION LOCATION in consideration from DSA Chapter 3, Table 3.4-1.

2. Calculate the maximum allowable leak rate by dividing the allowable leak volume (gallons) by the allowed 30 day duration. Assume a conversion factor of 20 drops per mL and express the allowable leak rate in units of drops per minute.

3. If the actual leak rate is less than the maximum allowable leak rate calculated in item 2, it can be considered "Drip-wise" leakage.

In certain LEAK DETECTION LOCATIONS, it is physically possible for a low flow-rate leak to drain out of the LEAK DETECTION LOCATION without accumulating sufficient depth of liquid to cause actuation of a credited leak detection device. In these cases, the potential downstream location for accumulation of the leaked waste will have the same leak detection requirements as the first LEAK DETECTION LOCATION.

An example of the above is FDB-3. This DB has a drain in the bottom of its sump, which directs waste to FDB-2. The drain in FDB-3 does not have a weir or similar device to ensure the accumulation of some minimal depth of liquid within FDB-3 before the liquid can drain to FDB-2. Thus, transfers through FDB-3 which require leak detection would require FDB-2 to be a LEAK DETECTION LOCATION.

Leak detection from a secondary containment is not considered and is not required per the DSA since it is a tertiary protection. As an example, leak detection box (MLDB-4) between FDB-3 and FDB-2 drain line is not required.

A further explanation for LEAK DETECTION LOCATIONS and the Safety Basis requirements placed on the locations is provided in Attachment-1, LEAK DETECTION LOCATIONS.

IMPLEMENTATION:

The TRANSFER PATH includes all piping branches up to the first sound isolation point (e.g., closed valve, blank, dummy Hanford connector, evaporator COP blanks). Blanks shall be qualified per ASME B31.3.

A primary containment waste location (waste tank, pump tank, evaporator pot) or another sound isolation point (e.g., closed valve, blank, dummy Hanford connector, evaporator COP blanks) downstream of the first sound isolation point shall also be identified. If the first sound isolation point is a blank, leak-tested valve or dummy Hanford connector, another sound isolation point or primary containment waste location is not required.

Only manually operated valves can be used for TRANSFER PATH determination since back-fit analysis (G-BFA-G-00034) was performed for manual valves only. However, if any pneumatic valves are seismically qualified for operability, it is acceptable to use them for TRANSFER PATH determination.

"Drip-wise" leak detection can be difficult if it is raining during the transfer due to rainwater intrusion. The Shift Manager and Shift Technical Engineer shall evaluate the conditions at the time (rate of increase in the secondary containment, transfer duration, etc.) and determine appropriate actions such as transfer shutdown, camera inspection, etc. The DSA did not credit structural integrity of evaporator system Jumpers in Evaporator Cells. Therefore, the drip-wise leakage limit is not applicable to evaporator operations.

DSA Section 3.4.1.5.2 lists inactive locations in which addition of waste into or WASTE TRANSFERS through are prohibited (transfers out are permitted). WASTE TRANSFERS into these locations and WASTE TRANSFERS through lines for which the locations are LEAK DETECTION LOCATIONS are prohibited (WASTE TRANSFERS out of these locations are permitted). These inactive locations shall be isolated from WASTE TRANSFERS by a single leak-tested valve, sound double valve isolation, or a blank.

Further TRANSFER PATH determination is not needed for the following evaporator transfer operations:

- Evaporator feed from the feed tank to the evaporator pot for 16H evaporator.
- Evaporator lift from the evaporator pot to the concentrate/vent tanks for 16H evaporator.
- Evaporator cell sump to the evaporator feed tank for 16H evaporator.

The TRANSFER PATH for 16H evaporator feed goes directly from the feed tank to the evaporator pot. The 16H Evaporator lift TRANSFER PATH goes directly from the evaporator pot to the concentrate/vent tanks through the associated Gravity Drain Line (GDL). Steam and air supply to alternate lift is blanked off when it is not in use. The 16H Evaporator cell sump jet TRANSFER PATH goes directly from the cell to the evaporator feed tank. For these TRANSFER PATHS all transfers are LOW-REM WASTE TRANSFERS (no LCO required LEAK DETECTION LOCATIONS), no other piping branches and no other primary

containment acceptable waste locations are in the path. Therefore, no further TRANSFER PATH determination is needed for these transfers.

For the TRANSFER PATHS discussed above for the 25H evaporator, all transfers are LOW-REM WASTE TRANSFERS (no LCO required LEAK DETECTION LOCATIONS). However, other piping branches and primary containments acting as acceptable waste locations are in the path. Therefore, independent verification of correct TRANSFER PATH alignment is required for the 25H evaporator associated transfers.

Following maintenance activities on a TRANSFER PATH component (valve, jumper, etc.) it may be necessary to transfer waste through the TRANSFER PATH instead of completing a leak test with water. It is acceptable to use waste to perform the leak test for declaring the TRANSFER PATH component OPERABLE if operational controls are implemented to minimize the risk of the TRANSFER PATH component inoperability leading to an accident. This is accomplished by having a camera inspection of the locations being leak checked during the transfer. If a greater than 'drip-wise' leak is spotted, the transfer shall be immediately stopped. Since this is part of declaring the TRANSFER PATH component OPERABLE, it is not required to be reported in ORPS. These actions are in compliance with LCO 3.0.5 for returning inoperable equipment to service. Once the component has successfully passed the leak check, the TRANSFER PATH component may be considered OPERABLE.

The WASTE TRANSFER definition per TSR Section 1.2 is as follows.

> "The planned movement of liquid waste along a TRANSFER PATH. This includes movement of waste caused by pumping, jetting, siphoning, or transfer jet/pump flushing activities (via jet entrainment or siphoning). If a transfer of water is known to have a waste siphon potential, the transfer shall be considered a WASTE TRANSFER. A transfer that originated as a non-waste transfer (at the time of TRANSFER PATH determination) does not have to be revised to a WASTE TRANSFER as a result of picking up contamination along the transfer route. If a transfer of non-waste is known to have a waste siphon potential, the transfer shall be considered a WASTE TRANSFER.
>
> Transfers from secondary containment sumps are considered to be WASTE TRANSFERS unless the sump contents have a sufficiently low inhalation dose potential that any release could not challenge the Evaluation Guidelines.
>
> Activities such as removal of contaminated rainwater in-leakage from inactive locations (stated in Administrative Control 5.8.2.43) are not considered to be WASTE TRANSFERS.
>
> Liquid transfers do not have to be considered WASTE TRANSFERS if the transfer stream can be demonstrated to meet the non-waste transfer criteria described in DSA Section 3.4.1.5.1.
>
> Examples of transfer streams that have been shown to not be WASTE TRANSFERS include a) transfers from the CST Facility (CSTF) to the Saltstone Facility, b) transfers from the ETP to CSTF, c) transfers of CSTF Evaporator Overheads to the ETP, and

d) transfers into Tank 50 which have inhalation dose potentials less than or equal to 2.09E+05 rem/gal. Transfers from CSTF to the Saltstone Facility shall comply with the Waste Acceptance Criteria and with Administrative Control 5.8.2.47.

Venting and draining of transfer lines associated with a LOW-REM WASTE TRANSFER where there is no potential to siphon waste are not considered a WASTE TRANSFER. However, venting and draining of transfer lines associated with a HIGH-REM WASTE TRANSFER is considered a WASTE TRANSFER.

In addition to the WASTE TRANSFER TSR definition, the following guidance is provided by the TSR for sump transfers. Transfers out of sumps associated with the TRANSFER PATH of a HIGH-REM WASTE TRANSFER shall be assumed to be HIGH-REM WASTE TRANSFERS (unless the liquid is shown to have inhalation dose potential less than 2.0E+08 rem/gal). Transfers out of these sumps at other times shall be assumed to be LOW-REM WASTE TRANSFERS, unless the sump contents have a sufficiently low inhalation dose potential that any release could not challenge the Evaluation Guidelines.

Simultaneous transfers with sound single valve isolation between them are permitted. This practice is acceptable since transfer events will be independently monitored by the material balance for each transfer.

For CONTINGENCY TRANSFERS, the flexible hose-in-hose is not required to be seismically qualified though it is not expected to leak in a Seismic Event. The risk of allowing waste to leak from a waste tank and remain in the annulus is judged more significant than the risk of failure of the Contingency Transfer System hose-in-hose transfer line during a Seismic Event (See DSA Section 3.4.2.18.1 SCENARIO DEVELOPMENT - *Transfers Lines*).

Implementation Items:

1. Prior to TRANSFER INITIATION, determine the TRANSFER PATH based on all piping branches up to the first sound isolation point (e.g., closed valve, blank, dummy Hanford connector, evaporator COP blanks). Also identify the primary waste containment waste location (e.g., waste tank, pump tank) or another sound isolation point downstream of the first sound isolation valve. If the first sound isolation point is a blank, leak-tested valve, or dummy Hanford connector, another sound isolation point or primary containment waste location is not required.

2. Deleted.

3. All PROCESS AREAS and LEAK DETECTION LOCATIONS needed to support the transfer shall be identified. All identified leak locations shall comply with the requirements of transfer related LCOs 3.7.1, 3.7.2, 3.7.3, 3.7.4, 3.7.5, 3.7.7, 3.7.10, 3.7.11, 3.7.12, 3.7.14 and/or 3.8.6.

4. The transfer procedure shall include the line/segment/CLI numbers associated with the TRANSFER PATH and piping downstream of the first sound isolation point up to the second sound isolation point or PROCESS AREA. If the first sound isolation point is a blank, leak-tested valve, or dummy Hanford connector, line/segment/CLI numbers associated with piping downstream of the first sound isolation point are not required.

5. Verify the structural integrity (seismic qualification) of the transfer lines along the TRANSFER PATH and piping downstream of the first sound isolation point up to the second sound isolation point or PROCESS AREA using the CST Master Equipment List (MEL) or Asset and Information Management (AIM) database or Smart Plant Foundation (SPF) during the transfer procedure development. If the first sound isolation point is a blank, leak-tested valve, or dummy Hanford connector, verification of structural integrity of piping downstream of the first sound isolation point is not required.

6. Identify any excavations along the TRANSFER PATH and piping downstream of the first isolation point up to the primary waste containment location (e.g., waste tank, pump tank) or another sound isolation point prior to transfer. Verify that the transfer lines in the excavation are evaluated for structural integrity and document the transfer lines are seismically qualified. If the first sound isolation point is a blank, leak-tested valve, or dummy Hanford connector, the identification of excavations downstream of the first sound isolation point is not required.

7. The transfer procedure shall verify that the line/segment/CLI numbers associated with the TRANSFER PATH and piping downstream of the first sound isolation point up to the second sound isolation point or PROCESS AREA are tested as prescribed by the Structural Integrity Program (TSR AC 5.8.2.12) prior to initiating the transfer. If the first sound isolation point is a blank, leak-tested valve, or dummy Hanford connector, verification of line/segment/CLI numbers associated with piping downstream of the first sound isolation point is not required.

8. When FDB-4 is on the TRANSFER PATH and requires leak detection instrumentation, FPP-2 shall be identified as a LEAK DETECTION LOCATION since FDB-4 drains to FPP-2 prior to being detected in FDB-4.

9. When FDB-3 is identified as a LEAK DETECTION LOCATION, FDB-2 and FPP-1 shall be also identified as LEAK DETECTION LOCATIONS since FDB-3 could drain to FDB-2 and FPP-1 prior to being detected in FDB-3.

10. When FDB-2 is identified as a LEAK DETECTION LOCATION, FPP-1 shall be also identified as LEAK DETECTION LOCATION since FDB-2 could drain to FPP-1 prior to being detected in FDB-2.

11. When HDB-2 is identified as a LEAK DETECTION LOCATION, HPP-3 shall be also identified as a LEAK DETECTION LOCATION since HDB-2 could drain to HPP-3 prior to being detected in HDB-2.

12. When a transfer line is designated as Out-of-Service, ensure that it is isolated from a waste TRANSFER PATH by a single leak-tested valve, sound double valve isolation, or a blank.

13. Inactive locations as specified in TSR Administrative Control 5.8.2.43.a shall be isolated from WASTE TRANSFERS by a single leak-tested valve, sound double valve isolation, or a blank.

14. When Tank 49 Valve Box is identified as a LEAK DETECTION LOCATION, the LDB Drain Cell shall be identified as a LEAK DETECTION LOCATION since Tank 49 Valve Box could drain to the LDB Drain Cell prior to being detected in Tank 49 Valve Box.

15. Prior to TRANSFER INITIATION through HDB-7, isolation shall be established in HDB-7 (single leak-tested valve, double valve isolation, blank or jumper removal) to preclude waste from entering the Tank 50 Valve Box except during intended transfers from HDB-7 to the Tank 50 Valve Box.

16. Prior to TRANSFER INITIATION from Tank 50, isolation shall be established in the Tank 50 Valve Box (single leak-tested valve, double valve isolation or blank) to preclude Tank 50 material from entering the HDB-7 and HDB-8 (via ETP Diversion Box).

17. Prior to TRANSFER INITIATION from SWPF to Tank 50, isolation shall be established in the Tank 50 Valve Box (single leak-tested valve, double valve isolation or blank) to preclude SWPF material from entering the HDB-7 and HDB-8 (via ETP Diversion Box).

4.4 SUBMERSIBLE BLENDER PUMP (SBP) OPERATION (TSR 5.8.2.58) (SAC)

ATTRIBUTE REQUIREMENTS: 5.8.2.58.a,b

The suction of the SBP shall be a minimum of 152 inches from the sludge layer during SBP operation.

The speed of the SBP shall be less than or equal to 860 rpm during SBP operation.

Additional controls shall be implemented as necessary to minimize the amount of sludge solids in suspension during SBP operation based on evaluation of the following phenomena:

- Tank agitation
- Effects of receiving WASTE TRANSFERS

IMPLEMENTATION:

The SBP Operation Program ensures the entrained waste has less than or equal to 1 wt% sludge solids and protects assumed initial conditions during SBP operation.

Sludge levels can be determined by measurement, visual inspection, or by engineering evaluation. Engineering shall identify the selected methodology.

When selected, engineering evaluation for sludge level determination shall address the following attributes, as applicable:

- Process knowledge (e.g., transfer history, operational conditions)
- Historical sludge level determination
- Waste tank sample results
- Uniformity of the solids level

In order to keep the entrained sludge solids less than or equal to 1 wt%, no WASTE TRANSFERS will be received during the SBP operation.

The speed of the SBP shall be less than or equal to 860 rpm during SBP operation. VFD speed check shall be performed prior to SBP operation. This check requires second person verification.

Implementation Items:

1. Prior to SBP operation, verify that SBP suction is greater than 152” above the sludge layer.
2. Prior to SBP operation, verify that no WASTE TRANSFERS are being received.

3. Verify that SBP is not operating prior to receiving WASTE TRANSFERS into a waste tank with SBP.

4. Prior to SBP operation, verify VFD maximum speed setting is less than or equal to 860 rpm.

5. Prior to SBP operation, a second person verification of VFD maximum speed setting of 860 rpm is required.

4.5 INDEPENDENT VERIFICATION OF CORRECT TRANSFER PATH ALIGNMENT (TSR 5.8.2.21) (SAC AS NOTED)

ATTRIBUTE REQUIREMENTS: 5.8.2.21.f,m

Prior to TRANSFER INITIATION, independent verification of correct TRANSFER PATH alignment shall be completed. After initiating the transfer, use of correct motive force shall be independently verified. This attribute is applicable to CONTINGENCY TRANSFERS also.

Prior to jetted TRANSFER INITIATION, independent verification of jet discharge path valves being open shall be completed (for jets with a 3-way valve, valve position will be in the discharge or receipt position, as applicable). Verification of jet discharge path being open is a SAC.

> DSA Section 3.4.1.5 states general CSTF inputs & assumptions and Section 3.4.1.5.6 lists the general controls required to protect general assumptions upon which the accident analyses calculations are based on. Independent verification of correct TRANSFER PATH alignment is one of the general controls listed in DSA Section 3.4.1.5.6 and needs to be protected.
>
> Verification of the jet discharge path being open prevents certain accidents associated with jetted transfers (e.g., aerosolization events). The jet discharge path can be closed during water flushing of the jet.

IMPLEMENTATION:

This administrative control is applicable to all WASTE TRANSFERS.

TRANSFER PATH alignment verification can be performed by verifying valves are in the open position between the transferring location and receiving location. Sound isolation valves in the closed position in the TRANSFER PATH can be verified by reviewing system alignment checklists since system alignment checklists are independently verified. Independent verification can be performed by a second person (separated by time and distance), camera verification or peer verification.

Independent verification of correct motive force can be performed by a second person (separated by time and distance) or peer verification. Methods of independent verification can be prime-mover switch position, prime-mover “run” indicator light, level changes in transfer and/or receiving location, etc. Independent verification of motive force shall be performed for all WASTE TRANSFERS, including the flushing of transfer jets from the Gang Valve (due to the potential to move waste out of the PROCESS AREA boundary) except in the case where the WASTE TRANSFER is due to a siphon potential (flush water pumps during flushing, leak checking, etc.).

Some transfers (sump transfers, evaporator cell sump operations, evaporator gang valve operations for flushing GDLs & Vent lines and pot siphon, flushing pump tank jets) are short in duration and may not last long enough to be able to perform independent verification by a second person (separated by time and distance). Therefore, these transfers motive force independent verification can be performed by the same person by verifying another parameter of the transfer such as level decrease from the sump or level increase in the receiving location, etc. If the verification cannot be performed promptly, the sump transfer shall be stopped.

For TRANSFER PATHS that require no valving (dedicated line [e.g., Evaporator Recycle Transfers]), the TRANSFER PATH is defined during the technical review process and is integral to the procedure content (flow path, siphon evaluation, etc.) Design prints are used to define the TRANSFER PATH, including jet orientation. The SR/QR of the technical review accomplishes the IV for the design feature(s) (e.g., jet orientation, jumper installation) of the TRANSFER PATH, meeting the requirements of TSR AC 5.8.2.21.f as it applies to TRANSFER PATH alignment. Changes to plant design follow the E7 Manual and would recognize procedure impacts during the technical review for the planned modification. A step in the transfer procedure for these dedicated line(s) (and associated IV) is NOT required to meet this control.

Independent verification of correct TRANSFER PATH alignment is not needed for the following evaporator transfer operations:

- Evaporator feed from the feed tank to the evaporator pot for 16H evaporator.
- Evaporator lift from the evaporator pot to the concentrate/vent tanks for 16H evaporator.
- Evaporator cell sump to the evaporator feed tank for 16H evaporator.

The TRANSFER PATH for 16H evaporator feed goes directly from the feed tank to the evaporator pot. The 16H Evaporator lift TRANSFER PATH goes directly from the evaporator pot to the concentrate/vent tanks through the associated Gravity Drain Line (GDL). Steam and air supply to alternate lift is blanked off when it is not in use. The 16H Evaporator cell sump jet TRANSFER PATH goes directly from the cell to the evaporator feed tank. For these TRANSFER PATHS all transfers are LOW-REM WASTE TRANSFERS (no LCO required LEAK DETECTION LOCATIONS), no other piping branches and no other primary containment acceptable waste locations are in the path. Therefore, independent verification of correct TRANSFER PATH alignment is not needed for these transfers.

For the TRANSFER PATHS discussed above for the 25H evaporator, all transfers are LOW-REM WASTE TRANSFERS (no LCO required LEAK DETECTION LOCATIONS). However, other piping branches and primary containments acting as acceptable waste locations are in the path. Therefore, independent verification of correct TRANSFER PATH alignment is required for the 25H evaporator associated transfers.

Performing the independent verification of correct motive force within 30 minutes will ensure that the transfer error will be detected prior to reaching 15,000 gallons maximum missing waste.

Implementation Items:

1. Transfer procedures shall include IV of correct TRANSFER PATH alignment (e.g., valves in the open position between the transferring location and receiving location, sound isolation points in the TRANSFER PATH) prior to initiation of the transfer. This item is not required for 16H evaporator transfer operations.

2. Transfer procedures shall include IV of starting of the correct motive force within 30 minutes of the TRANSFER INITIATION.

3. For short duration transfers (sump transfers, evaporator cell sump operations, evaporator gang valve operations for flushing GDLs & Vent lines and pot siphon, flushing pump tank jets), correct motive force verification can be performed by the same person by verifying another parameter such as sump level decrease, etc. If the verification cannot be performed promptly, the sump transfer shall be stopped.

4. Flushes of a transfer jet from the Gang Valve shall include verification of the correct motive force within 30 minutes of the TRANSFER INITIATION.

5. Prior to jetted TRANSFER INITIATION, independent verification of jet discharge path valves being open shall be completed. For jets with a 3-way valve, valve position will be in the discharge or receipt position, as applicable.

4.6 SIPHON EVALUATION (TSR 5.8.2.21)

ATTRIBUTE REQUIREMENT: 5.8.2.21.e

Prior to transfer initiation, a siphon evaluation shall be performed prior to any WASTE TRANSFER. The evaluation shall identify the potential for siphons and identify methods/ equipment needed to stop siphons.

The transfer system in both H and F Tank Farms consists of transfer lines that interconnect waste tanks, pump tanks, diversion boxes, pump pits, and valve boxes. Due to changes in elevations (flow from higher level to a lower level) along a given transfer route, there is a potential for a siphon to occur after the prime mover is stopped (Reference 8). This can occur due to submerged inlet down-comers which have no vent opening above the liquid level or due to a submerged transfer jet or transfer pump which has either no siphon break or has a siphon break that may be plugged. Siphons may also occur to or from a leaking or left open single valve isolating tanks depending on the specific physical elevation and piping configuration.

When a siphon occurs, the Control Room Operator typically has no direct/automatic method to immediately stop the liquid movement. Generally, field work (e.g., closing a diversion box valve or loosening the jet connector) is required to stop or break the siphon. The time necessary to recognize a siphon is occurring, determine the appropriate method(s) to stop or break the siphon, obtain any necessary tools, and perform the necessary field work could result in waste being released above-ground. Therefore, it is necessary to include instructions for stopping and breaking the siphon in a procedure and to stage any required equipment.

Siphon evaluations are not required for CONTINGENCY TRANSFERS because the only flow path for CONTINGENCY TRANSFERS is directly between the waste tank annulus and the waste tank vapor space.

Siphon evaluations are not required for TCCR TRANSFERS.

IMPLEMENTATION:

All transfer routes with the exception of sump transfers and transfers out of the evaporators, with a siphon potential shall have a valve in the siphon path available to stop the siphon liquid flow or a procedural contingency to break the siphon is required if a valve is not available. In addition to the valve that can stop the siphon, the capability to vent the siphon flow path at an elevation higher than the level in the tank being siphoned from (e.g., passive siphon break located at least 2 inches higher than the tank High Liquid Level Conductivity Probe (HLLCP) setpoint, vent path to a vented location, ability to break the jet connector heads at both nozzles) is required to break the siphon. The methods to 1) stop, and/or 2) break, any potential siphon shall be identified in the siphon evaluation and specified in the transfer procedure. Any required equipment (e.g., valve T-handle, connector head wrench) shall be staged prior to the transfer and available during the transfer. Sump transfers and leak checks of jumper nozzle connections typically do not have valves to stop the siphon. Since sump transfers are small in volume, the sump transfer

procedures can preclude siphon potential by other methods such as controlling the receiving tank levels when a valve is not available. Transfers out of the evaporators are not initiators to a waste tank overflow accident and therefore do not require Safety Significant devices to stop the transfers and siphons. If a passive siphon break and a closed valve exist in the unintended path, it can be considered to have no siphon potential from that tank since it requires double failure of both the siphon break and the closed isolation valve to initiate the siphon. If a passive siphon break along with a closed isolation valve is used to eliminate the siphon potential, the siphon break location shall be at least 2 inches higher than the tank HLLCP setpoint. Two inches above the HLLCP setpoint will account for the setpoint uncertainties. Pneumatic valves can only be identified to stop the siphon if they are seismically qualified for operability. Stopping an unintended siphon shall be completed as soon as practical based on plant conditions through the use of the appropriate transfer procedure. Once the siphon has been stopped the need for a rapid response is no longer required, thus the breaking of the siphon is not time dependent.

Implementation Items:

1. Perform and document the siphon evaluation for intended transfer.

2. Provide instructions in the transfer procedures to stop or break the siphon and to stage the equipment needed to stop the siphon as required.

3. If a passive siphon break along with a closed valve is used to eliminate the siphon potential from a tank, or is credited to vent and break a potential siphon from a tank, verify that the passive siphon break is located at least 2 inches above the HLLCP setpoint.

4.7 TRANSFER PUMP SPEED EVALUATION (TSR 5.8.2.21)

ATTRIBUTE REQUIREMENT: 5.8.2.21.e

Prior to transfer initiation, a transfer pump speed evaluation shall be performed. The evaluation shall identify the potential for over-pressurization of the Transfer Path (exceeding system design pressure) or exceedance of Transfer Path flow rate limitations and identify methods/equipment needed to prevent the identified potential.

A Variable Frequency Drive (VFD) speed setting (or operating speed for single Speed pump) check shall be performed prior to any liquid transfer using a transfer Pump. The check shall ensure that the maximum speed setting /operating speed is less than or equal to the value allowed to protect the most limiting of the following:

- Ensure system design pressure (or pressure permitted by an approved engineering evaluation) is not exceeded (excluding TCCR TRANSFERS as defined in DSA section 3.4.1.5.1).

- Ensure flow rate is less than or equal to 360 gallons per minute (gpm) at the first above-ground leak location (the point of lowest system resistance that results in leakage outside the tank, assuming a guillotine break of the piping), less than or equal to 220 gpm for TCCR TRANSFERS.

- Ensure flow rate is less than or equal to 250 gpm for the intended Transfer Path (assuming intact path) (excluding TCCR TRANSFERS as defined in DSA section 3.4.1.5.1).

This attribute is also applicable to CONTINGENCY TRANSFERS and TCCR TRANSFERS.

Some of the transfer pumps are equipped with Variable Speed/Variable Frequency Drives (VSD/VFD) or Adjustable Frequency Drive (AFD). These drives could produce transfer line pressures higher than the design pressure of the transfer system piping, if the pump speed exceeds the maximum setting and the transfer line is blocked. Therefore, transfer pump speed evaluation of the TRANSFER PATH shall be performed prior to any liquid transfer involving pumps. The evaluation shall determine the maximum pump speed setting (or operating speed for single speed pump) to ensure the design pressure for the transfer piping system (or pressure permitted by an approved engineering evaluation) is not exceeded. It shall also be acceptable to perform a one-time engineering evaluation/calculation which determines that over-pressurization and exceeding the maximum flow rates is not possible for a pump/pump drive combination.

Also transfer pump speed shall be set to limit the system flow rate (assuming intact path) to 250 gpm for waste tank transfer pumps to meet the DSA Section 3.4.1.5.2 requirement of 15,000 gallons maximum missing waste and detection/response time of 60 minutes.

For transfer pump flow rates, 360 gpm represents the highest allowable flow rate in an above-ground (or excavated) transfer line. The maximum speed for transfer pumps, calculated at the first above-ground leak location (the point of lowest system resistance that results in leakage outside the tank, assuming a guillotine break of the piping) prevents exceeding this flow rate. For pumps with Variable Frequency Drives (VFDs), the maximum transfer pump speed relies on limiting the speed on the VFD and verifying the speed setting is correct and functional prior to initiating the transfer. Single speed pumps that have no VFD, must meet the 360 gpm criteria at the pump operating speed. The transfer pump speed setting check is performed per this PDD. The 360 gpm is calculated based on the transfer pump location, such that the elevation difference from the pump to the break location is considered. The 360 gpm flow rate is protected at the first above-ground break location.

Transfer jet flow rate is highly dependent on plant conditions, including jet submergence, specific gravity of material being transferred, and steam supply pressure. In general, transfer jets have a flow rate less than transfer pumps, and significantly below transfer path flow rate limitations. The normal steam supply pressure to transfer jets is such that the transfer system design pressure will not be exceeded. Therefore, no evaluation is required for flow rate limitations or over-pressurization potential of the transfer path for jetted transfers.

Reference 28 evaluated Inhibited Water (IW) and Flush Water (FW) system pumps that can exceed transfer system design pressure. Based on this evaluation, operation of these pumps is acceptable and will not cause over-pressurization of the transfer system (pressures are within code allowable).If the required VFD speed setting (or operating speed for single speed pump) could cause the transfer system design pressure to be exceeded, an engineering evaluation shall be completed and provided to DOE.

For TCCR TRANSFERS, a VFD speed setting check shall be performed prior to liquid transfers using the transfer pump. The check shall ensure that the maximum speed setting is less than or equal to the value allowed to ensure the flow rate is less than or equal to 220 gpm at the first above-ground leak location (the point of lowest system resistance that results in leakage outside the tank, assuming a guillotine break of the piping).

The flow rate limit is not required for pump tanks due to limited volume of the pump tanks and incoming flow rates.

IMPLEMENTATION:

The following methodology shall be used for transfer system over-pressurization evaluation and maximum pump speed setting:

1. Determine ASME Code design pressure (or pressure permitted by an approved engineering evaluation) of the piping system.

2. Calculate maximum design pressure head in ft. based on the piping code pressure and pumped fluid and static head in ft. (elevation).

3. Calculate maximum pump speed (rpm) that develops pump shut-off head equal to the allowable design pressure head (ft) in item 2 using pump curves.

4. Calculate the transfer pump speed to limit the maximum system flow rate (assuming intact path) to 250 gpm for all waste tank transfer pumps.

5. Calculate the pump speed to limit the maximum flow rate to 360 gpm (220 gpm for TCCR TRANSFERS) at the first above ground (or excavated) leak location (the point of lowest system resistance that results in leakage outside the tank, assuming a guillotine break of the piping) for waste tank transfer pumps.

6. For pump tank transfer pumps, set the VFD/VSD/AFD maximum speed lower than or equal to the calculated maximum pump speed in item 3.

7. For waste tank transfer pumps, set the VFD/VSD/AFD maximum speed setting lower than or equal to the pump speeds calculated in items 3, 4, and 5 whichever is smaller.

8. Verify that the VFD/VSD/AFD maximum speed setting is lower than or equal to the maximum pump speed in items 6 or 7 prior to the transfer.

9. Verify the VFD/VSD/AFD maximum speed setting by attempting to ramp up beyond the maximum speed (challenge test) prior to the transfer.

10. If the transfer pump speed evaluation concludes that over-pressurization and maximum flow rate (as applicable) will not occur at any setting, then verification of VFD/VSD/AFD maximum speed setting is not required.

11. If the required VFD speed setting (or operating speed for single speed pump) could cause the transfer system design pressure to be exceeded, an engineering evaluation shall be performed and provided to DOE.

12. Reference 37 evaluated the potential for over-pressurization of F-Tank Farm waste transfer lines during H-Tank Farm to F-Tank Farm waste transfers. Based on this evaluation the following requirements shall be implemented during the H-Tank Farm to F-Tank Farm waste transfers to not exceed the F-Area Transfer lines ASME B31.3 over-pressure allowance:

    a. HPT-7 transfer pump VFD maximum speed is limited to 2470 rpm during H-Tank Farm to F-Tank Farm Inter-area waste transfers to not exceed ASME B31.3, 133% over-pressure allowance during dead head conditions.

    b. Waste Transfer System Design Authority to track and monitor total hours of F-Tank Farm waste transfer lines exceeding design pressure via System Health Report to ensure compliance with ASME B31.3 section 302.2.4

c. H-Tank Farm to F-Tank Farm Inter-area waste transfer procedures shall include a step that if the transfer was shut down due to a pump dead-head condition, then notify the Waste Transfer System Design Authority Engineer for evaluation of potential system over-pressurization.

Implementation Items:

1. A transfer pump speed setting evaluation shall be performed for all intended liquid transfers using transfer pumps to ensure transfer system design pressure and applicable maximum flow rates are not exceeded. If the required VFD speed setting could cause the transfer system design pressure to be exceeded, an engineering evaluation shall be performed and provided to DOE.

2. If applicable, verify that the VFD/VSD/AFD maximum speed setting is lower than or equal to the over-pressurization or maximum flow rate (waste tanks) speed prior to the transfer (i.e., verification of VFD/VSD/AFD program maximum speed parameters).

3. If applicable, verify the VFD/VSD/AFD maximum speed setting by attempting to ramp up beyond the maximum speed (challenge test) prior to the transfer.

4. HPT-7 transfer pump VFD maximum speed is limited to 2470 rpm during H-Tank Farm to F-Tank Farm Inter-area waste transfers to not exceed ASME B31.3, 133% over-pressure allowance during dead head conditions.

5. Waste Transfer System Design Authority to track and monitor total hours of F-Tank Farm waste transfer lines exceeding design pressure via System Health Report to ensure compliance with ASME B31.3 section 302.2.4

6. H-Tank Farm to F-Tank Farm Inter-area waste transfer procedures shall include a step that if the transfer was shut down due to a pump dead-head condition, then notify the Waste Transfer System Design Authority Engineer for evaluation of potential system over-pressurization.

4.8 CORE PIPE PLUGGAGE DUE TO SALT SOLIDS FORMATION (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.n

Prior to jetted TRANSFER INITIATION from waste tanks or pump tanks where the possibility of core pipe pluggage due to salt precipitation exists, a sufficient flush (or drain) to prevent pluggage of the core pipe shall have been completed. Flushing is not required for subsequent jetted TRANSFER INITIATION if the suspension time is within the requirements of the engineering evaluation (evaluation shall include the amount of time the transfer may be suspended before flushing is required).

> DSA Sections 3.4.2.10 and 3.4.2.13 credit this control to prevent aerosolization and waste tank/pump tank overheating events during jetted WASTE TRANSFERS. An evaluation of core pipe pluggage due to salt solids formation is required if the jet transfer out of a salt waste tank is performed. The evaluation shall include the maximum amount of elapsed time that the transfer may be suspended before flushing is required if pluggage is a possibility.

IMPLEMENTATION:

Salt-out evaluations will be performed for all waste tank and pump tank jet transfers to assess the possibility of core pipe pluggage due to salt solids formation if the transfer is shutdown. The evaluation will be performed per the methodology outlined in Reference 17. The salt-out evaluation will be based on the conditions of the supernate in the sending tank (chemical composition and temperature). The solubility of major salt species in the sending tank supernate will be used to assess the potential for salt-out. If the potential for salt-out exists, heat transfer rates between the transfer line and its surroundings will be utilized in order to determine how long the transfer can be shutdown before flushing must be initiated.

This requirement is not applicable to sump jet transfers.

During the performance of a transfer line flush associated with a transfer with a salt-out potential, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level change in the receipt vessel consistent with the derived flush volume. For situations where the required volume of the flush is such that the measuring device may not indicate an adequate change in level (e.g., small volume flush to a waste tank), the following items shall be performed to ensure flush completion:

- Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

- Confirm the level change in the sending vessel is consistent with the derived flush volume.

Piping branches off of the Transfer Path which did not have direct transfer flow through them (e.g., piping dead legs) are not required to have direct flush flow through them during flushing requirements. See Section 5.5.4.2.21 of the DSA for justification.

Implementation Items:

1. Perform a salt-out evaluation for jet transfers out of a waste tank or a pump tank to determine the potential for salt precipitation and core pipe pluggage potential.

2. If the evaluation determines that a pluggage potential exists for a jet transfer out of a waste tank or pump tank, ensure that the transfer procedure includes the requirements identified by the evaluation.

3. Implement the requirements identified by the evaluation by performing either item a OR items b.1 and b.2:

   a. During the performance of a transfer line flush associated with a salt-out potential transfer, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level/volume increase in the receipt vessel consistent with the derived flush volume.

   OR

   b.1. During the performance of a transfer line flush associated with a salt-out potential transfer, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level/volume decrease in the sending vessel consistent with the derived flush volume.

   AND

   b.2 Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

4.9 WATER HAMMER EVALUATION (TSR 5.8.2.21)

ATTRIBUTE REQUIREMENT: 5.8.2.21.e

Prior to transfer initiation, a water hammer evaluation shall be performed. This evaluation shall identify the potential for water hammer and identify methods/equipment needed to prevent water hammer. This attribute is applicable to CONTINGENCY TRANSFERS.

> Waste handling in the CSTF requires multiple transfers of liquid solutions or slurries containing radioactive waste. Waste is transferred between various PROCESS AREAS through transfer facilities (e.g., DBs, VB, HPFP, Pump Tanks). During transfers, water hammer may occur and could damage the transfer line core piping. Core piping integrity is credited for various accident analyses. A water hammer evaluation shall be performed for all WASTE TRANSFERS. It shall also be acceptable to perform a one-time engineering evaluation/calculation which determines the potential for water hammer and identifies methods and/or equipment needed to prevent its occurrence.

IMPLEMENTATION:

The methodology outlined in report M-ESR-S-00015 (Reference 21) or alternate engineering evaluation shall be used to determine the water hammer potential and any recommendations such as draining the transfer lines, high point venting and transfer pump start/restart criteria to prevent water hammer.

Implementation Items:

1. Perform and document the water hammer evaluation for the intended transfer consistent with the methodology in M-ESR-S-00015 (Reference 21) or alternate engineering evaluation.

2. Implement any actions such as draining the transfer lines, high point venting and transfer pump start/restart criteria identified in the water hammer evaluation to prevent the water hammer in the transfer procedures.

4.10 TANK RISER LEAK DETECTION (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: DSA Section 5.5.4.2.21.2.2

An evaluation for tank riser leak detection shall be performed for the associated TRANSFER PATH for HIGH-REM WASTE TRANSFERS. This evaluation shall be based on the availability/adequacy of the tank riser drain (i.e., drain/riser design is such that the riser will not overflow even in the event of a complete line break). The identified LEAK DETECTION LOCATIONS shall comply with the requirements of LCO 3.7.10.

> A loss of primary containment or incorrect transfer of waste could result in a transfer error event. The secondary containment identified in the Hazards Analysis as potential transfer error locations include waste tank annuli, DBs, VB, drain VB, PPs, catch tanks, the HPFP, LDB Drain Cell, waste tank transfer pump/jet risers, transfer line jackets, transfer line encasements, LDBs, MLDBs, and LPSs. Some waste tank transfer pump/jet risers are open at the bottom or have large drains, which excludes them from being potential transfer error locations. For these locations, a leak can be shown to not build up and plug the drain holes.

IMPLEMENTATION:

For HIGH-REM WASTE TRANSFERS, the waste tank transfer pump/jet risers that do not have adequate drain capacity shall be considered as LEAK DETECTION LOCATIONS and the leak detection equipment requirements of LCO 3.7.10 shall be followed. An evaluation of the drain adequacy shall be performed and documented. The evaluation shall ensure that the riser design will not allow the overflow even in the event of a complete line break in order to exclude it from being considered a LEAK DETECTION LOCATION. The methodology for the evaluation shall be that the calculated drainage flow rate be greater than the maximum pump/jet flow rate in the riser (examples: M-CLC-H-02172 for Tank 24 north riser, M-CLC-F-00688 for Tank 7 riser 4 and M-CLC-F-00790 for Tank 18 northeast riser).

Implementation Items:

1. When a tank jet/pump riser is in the TRANSFER PATH for a HIGH-REM WASTE TRANSFER, an evaluation shall be performed to determine whether it needs to be considered as a LEAK DETECTION LOCATION. If the riser shall be included as a LEAK DETECTION LOCATION for the HIGH-REM WASTE TRANSFER, it shall comply with the requirements of LCO 3.7.10.

2. If the evaluation in item 1 determines that the jet/pump riser is a LEAK DETECTION LOCATION for the HIGH-REM WASTE TRANSFER, the transfer procedure shall include the tank riser conductivity probe in accordance with LCO 3.7.10.

4.11 TRANSFER ISOLATION VALVE EVALUATION (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: DSA Section 5.5.4.2.21.2.11

Prior to each HIGH-REM WASTE TRANSFER, an evaluation of the associated transfer isolation valves shall be performed to ensure that the ability to stop transfers is maintained. If the isolation valve for a transfer has a Teflon seat, the evaluation shall include what, if any, additional measures need to be taken.

> Waste handling in the CSTF requires multiple transfers of liquid solutions or slurries containing radioactive waste. Waste is transferred between various PROCESS AREAS through transfer facilities (e.g., DBs, VBs, HPFP, Pump Tanks). Each transfer may go through several valves in various PROCESS AREAS to get to the intended location. There could be multiple ways to isolate the transfer from events such as siphon, transfer error, overflow, etc. For a HIGH-REM WASTE TRANSFER, an evaluation of the selected isolation valve shall be performed to ensure that it will isolate the transfer as required. Some of the valves in Tank Farms have Teflon components such as valve seats. Teflon does not have a high radiation resistance and is thus subject to degradation in the presence of a sustained high radiation field. The Teflon in these valves can swell and crack to a degree that could prevent the valve from being manipulated to a closed position. If the selected valve has a Teflon seat, an evaluation shall be performed. This evaluation shall consider the material being transferred in terms of dose potential to the Teflon parts and the expected duration of the transfer. These two considerations would establish the expected integrated dose to the Teflon parts which could then be compared to the damage threshold exposure dose level for Teflon. If this threshold were challenged, then perform the following to bring the integrated dose below the threshold level:
>
> 1. Limit integrated dose by limiting the transfer volume or reduce the dose potential, OR
>
> 2. Pick a new transfer route, OR
>
> 3. Pick a different valve, OR
>
> 4. Replace the Teflon parts or the valve.

IMPLEMENTATION:

Transfer isolation valves are located in various transfer facilities (e.g., DBs, VBs, HPFP, Pump Pits). These valves shall be listed in the CST MEL database. The database shall identify which valves are equipped with Teflon seats. If a Teflon seat valve is required for a HIGH-REM WASTE TRANSFER as an isolation valve, an evaluation will be performed and any compensatory measures required will be implemented.

Implementation Items:

1. For HIGH-REM WASTE TRANSFERS, identify the isolation valves to stop the flow to mitigate transfer events such as overflow or siphon.

2. If the required isolation valves for the HIGH-REM WASTE TRANSFER have Teflon seats, perform an evaluation for its acceptability and/or identify any compensatory/corrective measures.

3. Implement the compensatory/corrective measures identified in item 2.

4.12 SECOND ISOLATION DEVICE (TSR 5.8.2.21)

ATTRIBUTE REQUIREMENT: 5.8.2.21.i & DSA Section 5.5.4.2.21.2.12

Prior to TRANSFER INITIATION of a HIGH-REM WASTE TRANSFER, procedures shall identify two physically separated functional transfer isolation devices, each capable of stopping the transfer. The transfer isolation devices shall be sufficiently separated (by distance) such that the availability of one isolation device is maintained.

> Section 4.14 of this PDD requires an isolation device to stop the prime mover for all transfers. For HIGH-REM WASTE TRANSFERS, a second isolation device is required. These two isolation devices shall be separated by distance to prevent inaccessibility during and after a seismic event.

IMPLEMENTATION:

In H-Area Tank Farm, there are multiple devices to stop the motive force of a transfer. Electrical power to the pump motors can be secured from various locations.

The second isolation device shall be reasonably located away from the first isolation device to maintain accessibility of at least one of the devices as needed during and after a seismic event. The intent of a reasonable distance between the two isolation devices is to ensure the transfer can be shut down when one of the devices could not be reached due to seismic event.

Implementation Items:

1. For a HIGH-REM WASTE TRANSFER, identify a second isolation device such as any power supply isolation for the transfer pump motor to stop the motive force. This second isolation device should be reasonably located away from the first isolation device.

2. Provide instructions in the HIGH-REM WASTE TRANSFER procedures to use the second isolation device to stop the motive force if the first isolation device fails to stop the motive force.

4.13 FLUSHING THE CORE PIPE AFTER WASTE TRANSFERS (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.g,t

Within 30 days of completing a WASTE TRANSFER, a sufficient flush of the core pipe shall be performed such that the inhalation dose potential of the residual waste in the core pipe is less than or equal to 3.5E+07 rem/gal.

Prior to TRANSFER INITIATION of a HIGH-REM WASTE TRANSFER, a single line volume flush (with water) of the transfer line core pipe shall be performed. The pre-transfer flush shall be performed within 30 days of actual TRANSFER INITIATION.

If an evaluation indicates that the inhalation dose potential of the residual waste in the core pipe is less than or equal to 3.5E+07 rem/gal (including 2 Sigma uncertainty), flushing is not required. If flushing is required, the necessary flush volume and duration shall be determined. Flushing is not required if the time between transfers is less than 30 days (the 30-day completion time for the flush shall be based on completion of the last transfer).

IMPLEMENTATION:

Flushing of transfer lines is required within 30 days after a WASTE TRANSFER with an inhalation dose potential (including 2 Sigma uncertainty) greater than 3.5E+07 rem/gal. When comparing to the IDP limits, the conservative uncertainty values from Reference 32 can be used to lower the limit instead of calculating the IDP with uncertainty. IDP for flushing will be calculated in WCS and checked against the limit. Uncertainty of 100% from Reference 32 for supernate will be applied to the limit. Therefore, in WCS flushing of transfer lines will be required if IDP is greater than 1.75E+07 rem/gal.

If the WASTE TRANSFER is a batch transfer, a single flush after the last batch transfer is sufficient. The batch transfers shall not be separated by more than two weeks for the hydrogen buildup. However, if sludge-slurry settling / salt out criteria times are less than the batch duration, the lower time limit shall be used for flushing requirements. For SLUDGE SLURRY TRANSFERS, based on the recommendations of reports WSRC-RP-93-900-TL (Reference 22) and WSRC-RP-93-800 (Reference 23), three line volumes at a normal flush water system flow rate should dilute the sludge slurry by 99%. Report WSRC-RP-93-800 (Reference 23) concludes that sludge-slurry will not plug the line if the settling time is less than a week. For non-SLUDGE SLURRY TRANSFERS, one line volume at a normal flush water system flow rate should bring the core pipe residual waste IDP to less than 3.5E+07 rem/gal (including 2 Sigma uncertainty).

This requirement is not applicable to the transfer lines owned by other facilities.

During the performance of a transfer line flush associated with WASTE TRANSFER, and pre-transfer flush for HIGH-REM WASTE TRANSFER, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level change in the receipt vessel consistent with the derived flush volume. For situations where the required volume of the flush is such that the measuring device may not indicate an

adequate change in level (e.g., small volume flush to a waste tank), the following items shall be performed to ensure flush completion:

- Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

- Confirm the level change in the sending vessel is consistent with the derived flush volume.

Piping branches off of the Transfer Path which did not have direct transfer flow through them (e.g., piping dead legs) are not required to have direct flush flow through them during flushing requirements. See Section 5.5.4.2.21 of the DSA for justification.

Implementation Items:

1. SLUDGE SLURRY TRANSFER procedures shall require the transfer lines be flushed within 30 days of transfer completion with a minimum of three line volumes. If the SLUDGE SLURRY TRANSFER inhalation dose potential is less than or equal to 1.75E+07 rem/gal, flushing is not required.

2. Non-SLUDGE SLURRY TRANSFER procedures shall require the transfer lines be flushed within 30 days of transfer completion with one line volume. If the Non-SLUDGE SLURRY TRANSFER IDP is less than or equal to 1.75E+07 rem/gal, flushing is not required.

3. Prior to TRANSFER INITIATION of a HIGH-REM WASTE TRANSFER, a single line volume flush (with water) of the transfer line core pipe shall be performed. The pre-transfer flush shall be performed within 30 days of actual TRANSFER INITIATION

4. See Reference 12 (Corrosion Control PDD), Section 5.1.2, for additional Microbiologically Induced Corrosion (MIC) flushing requirements.

5. Implement the requirements identified by the evaluation by performing either item a OR items b.1 and b.2:

   a. During the performance of a transfer line flush associated with a WASTE TRANSFER and pre-transfer flush for HIGH-REM WASTE TRANSFER, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level/volume increase in the receipt vessel consistent with the derived flush volume.

   OR

   b.1. During the performance of a transfer line flush associated with a WASTE TRANSFER and pre-transfer flush for HIGH-REM WASTE TRANSFER, assurance that the flush water is being routed to the appropriate TRANSFER

PATH shall be achieved through positive confirmation of a level/volume decrease in the sending vessel consistent with the derived flush volume.

AND

b.2. Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

4.14 ISOLATION DEVICE TO STOP THE TRANSFER (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.h & DSA Section 5.5.4.2.21.2.11

Prior to TRANSFER INITIATION, procedures shall identify (including staging requirements) the functional equipment needed to stop transfers and siphons.

> Most transfers are terminated from a control room panel or Distributed Control System (DCS). For a steam gang valve transfer, the motive force is secured when the valves in the field move from the "steam" or "jet" position into the "air" position. After the pipes routing from the gang valve to the jet are air blown, the valves move to the "vent" position. This valve manipulation secures the steam from the jet eductor. In addition to securing the transfer from the control room panel using the gang valve controls, there are numerous manual valves located in the field which may be used as alternate means for securing steam to a transfer jet.
>
> For a transfer using a pump, the transfer is stopped when the electrical power to the pump motor is secured from the panel board or DCS. Electrical power to the pump motor can be secured from alternate locations if needed.
>
> For an air-driven jet/pump transfer, the motive force is secured when the air supply valves are closed. Other non-credited methods of securing the air supply exist if needed.
>
> For transfers that utilize a dedicated power source, the motive force is secured when the power source is secured (e.g., unplugging the power supply cord to an air compressor that supplies air to an air driven pump). If there is a reservoir between the compressor and the transfer pump, an evaluation shall be performed to ensure that the transfer will be stopped in a reasonable time. In this case, no specific equipment needs to be credited or identified.
>
> For jets using water as motive force, the transfer can be secured when the flush water supply valves are closed.

Equipment needed to stop transfers is applicable to CONTINGENCY TRANSFERS and TCCR TRANSFERS.

IMPLEMENTATION:

The waste tank transfer jet gang valves have manual isolation valves in the steam supply and air supply systems located upstream of the gang valves and manual isolation valves located in the jet line downstream of the gang valves. Depending on the gang valve isolation valve configuration, either the upstream or downstream isolation valve(s) is used to isolate steam, and air to the transfer jet. Selection of the isolation valves is based on operator accessibility and operation during accident and post seismic event conditions.

The transfer pumps and Evaporator feed pumps have various electrical components that can be used to manually interrupt electrical power to the motor. Dependent on the pump involved,

either the electrical supply breaker to the motor or the motor disconnect device is used as the device to interrupt electrical power to the pump motor.

Transfers out of the evaporators are not initiators to a waste tank overflow accident and therefore do not require Safety Significant devices to stop the transfers and siphons.

If a transfer jet gang valve discharge isolation valve is identified to stop the transfer, it will stop all motive forces (steam, air and water). If a steam isolation valve is identified to stop the transfer, it is possible to have air lift of the waste if air leaks through and proper elevations exist. For this condition, both steam and air isolation valves (including bypass valves if present) shall be identified to stop the transfer.

The manual cycling of the credited valves shall consist of fully closing the valve and then fully opening it (or vice versa if the valve is normally closed). This exercise of the valve ensures that the valve is not frozen and therefore able to be closed if required.

For Contingency Transfer System transfers and TCCR TRANSFERS, equipment to stop a siphon is not required. Additionally, equipment to stop transfers is not required for transfers into waste tanks for the following:

- Batch transfers less than 15,000 gallons (i.e., sending vessel is less than 15,000 gallons and does not have continuous makeup capability). The liquid source system shall be considered to have continuous makeup capability if the system has an automatic fill provision that is not electrically or mechanically isolated. The electrical or mechanical isolation shall contain two independent means of isolation (e.g., two isolation valves; one isolation valve and open disconnect for liquid source transfer pump). Liquid additions to the waste tank from the Dissolution Water Skid do not have continuous makeup capability as described in DSA Section 3.4.1.5.2.

- Siphons/lifts/pump-outs of the contents of an evaporator pot (if the evaporator feed pump is secured)

Stopping an unintended siphon shall be completed as soon as practical based on plant conditions through the use of the appropriate transfer procedure (typically accomplished by closing appropriate waste transfer valves). Once the siphon has been stopped, the need for a rapid response is no longer required and breaking the siphon is not time dependent. Therefore, the equipment called out in the siphon evaluation for breaking the siphon does not have to be stored near the affected TRANSFER PATH.

Transfer line isolation valves that are credited equipment used to stop transfers/siphons shall be specified in the procedure. Functionality of the valve(s) is proven by opening the valve(s) when initially establishing the TRANSFER PATH. This provides assurance that the valve(s) is capable of being manipulated and, in the event of a transfer error/siphon, will provide a credited method to stop the flow of waste. The transfer procedure will also require a check to ensure no facility conditions (e.g., NCRs, OOS list, temporary modifications, lock outs) will prevent the valve from performing its intended function.

Implementation Items:

1. Prior to TRANSFER INITIATION identify the isolation valve credited to stop steam, and air flow to transfer jets in the transfer procedure and verify that it is in service prior to transfer. If the steam isolation valve is identified as a credited valve, an air isolation valve must also be identified.

2. Prior to TRANSFER INITIATION identify the electrical isolation device credited to stop transfer pumps in the transfer procedure and verify that it is in service prior to transfer.

3. Prior to TRANSFER INITIATION identify the isolation valve credited to stop air flow to air-driven transfer jets/pumps in the transfer procedure and verify that it is in service prior to transfer.

4. Transfer procedures shall ensure that the credited valves identified in implementation items 1 and 3 are manually cycled prior to TRANSFER INITIATION.

5. Transfer procedures shall ensure operability of a valve credited with stopping a transfer or siphon during the initial TRANSFER PATH line up where the valve is opened to establish the TRANSFER PATH. If the valve is normally open as required by the System Alignment Check list, the valve must be closed and then re-opened.

6. Prior to TRANSFER INITIATION the transfer procedure shall verify the valve credited with stopping a transfer or siphon is available to be used (e.g., no OOS tags, lock outs, NCRs, temporary modifications).

4.15 TRANSFER MONITORING (TSR 5.8.2.21) (SAC AS NOTED)

ATTRIBUTE REQUIREMENT: 5.8.2.21.c,o,p

Monitoring and material balance requirements for WASTE TRANSFERS to detect transfer events shall be determined. The frequency and method (e.g., level/leak monitoring) of monitoring and material balances for a transfer and the required monitoring locations (including consideration of those past the first isolation point) shall be determined on an individual basis.

ACTUAL MISSING WASTE shall be less than or equal to 5,000 gallons. If ACTUAL MISSING WASTE is greater than 5,000 gallons, then the affected WASTE TRANSFERS shall be terminated immediately. This attribute is a SAC. This attribute is applicable to CONTINGENCY TRANSFERS.

Material balance discrepancies shall be less than or equal to 15,000 gallons. If material balance discrepancies are greater than 15,000 gallons, then the affected WASTE TRANSFERS shall be terminated immediately. This attribute is a SAC.

WASTE TRANSFERS shall be monitored periodically for indications of transfer events (i.e., transfer error, siphoning, and leakage). Monitoring shall extend beyond the TRANSFER PATH to locations (e.g., pump tanks and waste tanks) determined by evaluation. The evaluation to determine the monitoring locations beyond the TRANSFER PATH shall consider the isolation method used to define the TRANSFER PATH (e.g., non-leak tested valve versus leak-tested valve, double valve isolated, or blanked). The frequency and method (e.g., level/leak monitoring) of transfer monitoring and material balances for a transfer shall be determined on an individual basis and shall be commensurate with the transfer rate and transfer type (batch versus continuous).

WASTE TRANSFERS with the potential to transfer material in amounts greater than 15,000 gallons require material balances. In general, increased monitoring frequency is appropriate during the initial stages of the transfer, with a lesser frequency required once a transfer has been established. Material balances are not required for Contingency Transfer System transfers, or WASTE TRANSFERS involved with feed to and receipt from an evaporator. Contingency Transfer System transfers are transfers of waste from the annulus of a leaking waste tank back to the primary side of the same waste tank using the Contingency Transfer System. Material balances are required for evaporator recycle transfers.

> During WASTE TRANSFERS, leaks and spills can be detected by numerous instruments in the facilities. Available instruments include reel tapes, radar level detectors, Area Radiation Monitors (ARMs), Continuous Air Monitors, dip tubes, and conductivity probes (not all of these features may be present to detect waste in each location). These instruments shall be included in the transfer procedure as applicable. Other methods can be used to monitor for indications of transfer events. These methods include insertion of a video camera in the waste tank, using a reel tape to monitor tank level, parking a reel tape above the waste surface, etc. The different circumstances of each individual transfer shall be evaluated to determine which method is most effective.

In addition to level/leak monitoring above, material balances shall be performed as another means of detecting transfer events. The material balance cumulative difference may be reset to zero during the transfer or following a shutdown if the documented engineering evaluation is completed.

IMPLEMENTATION:

Waste transfers shall be monitored periodically for indication of transfer events often enough such that a leak of 15,000 gallons would be detected. A material balance shall be performed for all WASTE TRANSFERS with a potential volume of greater than 15,000 gallons (including siphon potential) with the exception of CONTINGENCY TRANSFERS or WASTE TRANSFERS involved with feed to and lifting from an evaporator. Material balance tolerances shall be prescribed in the transfer procedures. Small volume transfers from pump tanks to waste tanks should have a reasonably small material balance tolerance. Large volume transfers from a waste tank through numerous pump tanks and finally to another waste tank would most likely have a relatively large material balance tolerance. For this reason, each transfer or grouping of transfers shall prescribe an acceptable material balance tolerance in the transfer procedure. The Shift Manager, Shift Supervisor, and/or Shift Technical Engineer shall use this tolerance for determining if a transfer is being routed successfully.

A material balance discrepancy should be compared with other process data as well as the trend of the previous discrepancies during the same transfer, and consider the system flow rate and material balance frequency, to ensure the transfer is shut down before the DSA maximum missing waste volume is exceeded. Re-zeroing of material balances may be completed prior to reaching the applicable transfer procedure shut down criteria and shall include a documented technical basis. The primary means of re-zeroing shall be accomplished by verifying no indications of a waste leak in the transfer monitoring leak detection equipment (for LOW-REM WASTE TRANSFERS) or the LCO related LEAK DETECTION LOCATION (for HIGH-REM WASTE TRANSFERS. Resetting the cumulative material balance difference, during the transfer or following a shutdown, must be evaluated and approved with a documented engineering evaluation. This evaluation can be in the form of a position paper, engineering numbered memo or included as part of the transfer procedure. Approval for resetting to zero must be obtained from the Facility Manager or his designee. The evaluation should consider items such as validity of transfer data, functionality of instruments being used (reel tapes, radar level detectors, bubblers, etc.), calculation errors, transfer line hold ups, jet dilution estimates, evaporator operational parameter changes (feed rate, lift rate), salt mounds, salt on cooling coils, material balance of concurrent transfer that is single valve isolated, conical sections of Type III/IIIA Tanks (>299”), unexplainable level changes in other PROCESS AREAS, etc. If the evaluation cannot support re-zeroing of the material balance discrepancy, the transfer shall be shutdown. The material balance discrepancy shutdown criteria approved for the transfer procedure remains in effect and will continue to protect maximum missing waste assumptions of the DSA.

The frequency of the material balance is dependent on transfer rate (jet transfer vs. pump transfer) and type of transfer (batch vs. continuous). For jet transfers the average transfer rate is less than 100 gpm and pump tank transfer rate is 125 gpm. Most of the transfers are limited by either jet or pump tank transfer rates. Based on these transfer rates, a material balance shall

be performed every 2 hours. Material balance frequency for a waste tank to waste tank pump transfer without a pump tank shall be determined on a case by case basis. Also, the frequency of the material balances should be more often during the initial stages of the transfer when transfer events are more likely to occur and less frequently after the transfer is established. This increased frequency shall be accounted for when multiple prime movers are utilized for a WASTE TRANSFER and their start times are not the same. This is to ensure that all TRANSFER PATH segments are equivalently monitored when waste is first introduced. For short duration transfers (e.g., less than 1 hour) the material balance can be performed at the completion of the transfer. Different material balance frequencies for a specific transfer can be prescribed with an engineering justification.

For Inter Area Line (IAL) transfers, the first material balance can be performed after a level increase in the receipt tank (it may take longer than 1 hour due to number of pump tanks and transfer lines involved). Since IAL transfers normally start with water to verify the transfer route, it is acceptable to perform the first material balance 2 hours after start of the transfer.

16H evaporator transfer operations TRANSFER PATHS are dedicated to specific locations without going through any pump tanks, diversion boxes, valve boxes or drain valve boxes. TRANSFER PATH for evaporator feed goes directly from feed tank to the evaporator pot. Evaporator lift TRANSFER PATH goes directly from evaporator pot to concentrate/vent tanks through the associated GDL. Steam and air supply to alternate lift is blanked off when it is not in use. Evaporator cell sump jet TRANSFER PATH goes directly from cell to evaporator feed tank. Therefore, transfer events are minimized for these evaporator transfer operations and material balances are not required for these TRANSFER PATHS. However, during evaporator operations, feed and concentrate tank levels are monitored periodically for level changes. The COPs for 16H are not required to be monitored if the associated blanks are installed. The COP and associated leak detection are required to be monitored unless they have been removed from the TRANSFER PATH per the requirements of Section 4.3.

Material balance need not be performed during the temporary shutdown of the transfer provided that one is performed after the prime mover is stopped.

Waste tank levels using reel tapes/radar level detectors may not be accurate if slurry pumps/mixers are in operation. Means of obtaining an accurate material balance may include stopping the slurry pumps/mixers to get the reel tape/radar readings or establishing another method of obtaining material balance with slurry pumps/mixers in operation.

If the transfer involves two waste tanks receiving and transferring simultaneously from one tank to another (e.g., Tank 6 transfer to Tank 7 and back to Tank 6), material balance can be attained by comparing the change in levels in each of the tanks.

When securing the transfer, the expected drain back volume (in gallons or inches of tank level) shall be specified in the transfer procedure to aid in determining transfer events such as siphoning, line pluggage, equipment malfunctioning (closed/partially closed valve), etc. This drain back requirement is not applicable to the waste transfers to or from the evaporator pot due to the limited volume.

ACTUAL MISSING WASTE is WASTE TRANSFER material which is outside the primary containment boundaries of the planned TRANSFER PATH and is confirmed by instrumentation or visual inspection. ACTUAL MISSING WASTE does not apply to non-waste material which is outside the primary containment boundaries of the planned TRANSFER PATH during activities which are classified as a WASTE TRANSFER due solely to siphon potential. For this exclusion, it shall be confirmed that no material was siphoned from a waste tank or pump tank.

ACTUAL MISSING WASTE will be determined by performance of engineering evaluation if indications or installed instrumentation are not available to determine the amount of missing waste. This evaluation will determine the source of the waste and will be confirmed through the use of alternate instrumentation, observations, or calculations.

Determinations for ACTUAL MISSING WASTE will be part of the evaluations for resetting the cumulative material balance difference, during the transfer as described above. If the material balance can be re-zeroed, the transfer can continue until other shutdown criteria are met.

Once it has been determined that ACTUAL MISSING WASTE has been detected the transfer shall be shut down immediately. Flushing, venting and draining activities will only be allowed if it can be demonstrated that these activities cannot contribute additional ACTUAL MISSING WASTE.

Implementation Items:

1. Record TRANSFER PATH tank levels (waste tanks and pump tanks) every 30 minutes for the first 2 hours of the transfer and every 2 hours thereafter in the transfer procedure. Record the final levels at the end of the transfer. This is not applicable to evaporator transfer operations.

2. Record sump levels and single valve isolated path tank levels (waste tanks and pump tanks) every 30 minutes for the first 2 hours and every 12 hours thereafter in the transfer procedure. Record final levels at the end of the transfer.

3. Perform a material balance for WASTE TRANSFERS with a potential volume of > 15,000 gallons every hour for the first 2 hours of the transfer and every 2 hours thereafter. Also perform a final material balance at the shutdown of the transfer. The material balance frequency may be varied for unusual transfers (e.g., interstitial liquid removal, IAL transfers) depending on transfer rate and type of transfer etc.

4. For a short duration transfer (e.g., less than 1 hour), the material balance can be performed at the completion of the transfer.

5. If ACTUAL MISSING WASTE is detected, then the affected transfer shall be terminated immediately.

6. When securing a transfer (not to include normal evaporator operation transfers), the expected drain back volume (in gallons or inches of tank level) shall be specified in the transfer procedure. During the transfer shutdown, levels shall be monitored for the expected drain back and if the expected drain back is not received, the Shift Manager or his designee shall be notified for appropriate actions.

7. Transfer procedures shall verify that equipment used for transfer monitoring is functional prior to the transfer.

8. Material balance cumulative difference can be reset to zero at any time during the transfer or following a shutdown if a documented engineering evaluation is completed and approved by the Facility Manager or his designee. If the material balance discrepancy reaches 5000 gallons, an engineering evaluation shall be performed to attempt to re-zero the material balance.

9. During evaporator operations, feed and concentrate tank levels shall be monitored periodically (round sheets) for level changes.

10. If material balance discrepancies are greater than 10,000 gallons, then the affected WASTE TRANSFERS shall be terminated immediately.

4.16 WASTE TANK SPACE AVAILABILITY (TSR 5.8.2.21)

ATTRIBUTE REQUIREMENT: 5.8.2.21.j

Prior to TRANSFER INITIATION of a WASTE TRANSFER, verification of available waste tank space shall be performed.

This attribute is also applicable to TCCR TRANSFERS.

IMPLEMENTATION:

Waste tank liquid level is required to be less than or equal to tank specific fill limits specified in the ERD (Reference 20). Therefore, by verifying the receiving waste tank expected maximum final level is lower than HLLCP setpoint prior to the transfer will ensure that the tank specific fill limit is not exceeded. For WASTE TRANSFERS, this requirement is required by the DSA as a control to prevent a waste tank over flow. Due to the nature of evaporator operations (continuous operation), verification is not required for transfers to or from the evaporator pot.

Implementation Items:

1. Verify that the receiving waste tank expected maximum final level is lower than the HLLCP setpoint from the ERD (Reference 20) prior to the transfer and document in the waste transfer evaluation and approval procedure (not applicable to transfers to or from the evaporator pot).

2. Verify that the transfer procedure directs shutdown of the transfer prior to reaching the approved volume identified in the waste transfer evaluation and approval procedure (not applicable to transfers to or from the evaporator pot).

   OR

   For simultaneous transfers between two tanks, verify that the transfer procedure directs shutdown of the transfer prior to reaching the expected final level of either tank as identified in the waste transfer evaluation and approval procedure (not applicable to transfers to or from the evaporator pot or evaporator recycle transfers).

4.17 ESP SLUDGE SLURRY TRANSFERS (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.k,l, DSA Section 5.5.4.2.21.2.14,15 & DSA Section 5.5.4.2.43.2

ESP SLUDGE SLURRY shall only be transferred along the leak-checked paths shown in DSA Chapter 3, Figure 3.7-1. Within 30 days of completing ESP SLUDGE SLURRY transfers, a three line volume flush of the core pipe shall be performed. Flushing is not required if the time between transfers is less than 30 days (the 30-day completion time for the flush shall be based on completion of the last transfer). Steam jet transfers into an ESP SLUDGE SLURRY WASTE TANK are prohibited.

IMPLEMENTATION:

The only waste tanks permitted to be classified as an ESP SLUDGE SLURRY WASTE TANK are Tanks 40 and 51; all other waste tanks are prohibited from being classified as an ESP SLUDGE SLURRY WASTE TANK. ESP SLUDGE SLURRY may only be transferred along the leak-checked TRANSFER PATHS identified in DSA Chapter 3, Figure 3.7-1. None of the PROCESS AREAS associated with the TRANSFER PATH shown in figure 3.7-1 may be allowed back on the TRANSFER PATH until the flush discussed below is completed.

ESP SLUDGE SLURRY is defined as WASTE TRANSFER material that has a hydrogen generation rate greater than 1.5E-5 ft^3/gal-hr and less than or equal to 5.0E-5 ft^3/gal-hr. Classification of material as ESP SLUDGE SLURRY is independent of the inhalation dose potential of the material and is independent of the waste tank containing the material being classified as an ESP SLUDGE SLURRY WASTE TANK.

For ESP SLUDGE SLURRY transfers from Tank 51 to Tank 40, a three line volume flush of core pipe shall be performed to protect the assumed hydrogen generation rate for this TRANSFER PATH. The safety function of the three line volume flush after ESP SLUDGE SLURRY transfers is to reduce the hydrogen generation rate of material in the PROCESS AREAS affected by the ESP SLUDGE SLURRY transfer. The flush will ensure that the final hydrogen generation rate in the affected PROCESS AREAS is less than or equal to the bounding radiolytic hydrogen generation rate assumed for that location.

During the performance of a transfer line flush associated with ESP SLUDGE SLURRY transfer, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level change in the receipt vessel consistent with the derived flush volume. For situations where the required volume of the flush is such that the measuring device may not indicate an adequate change in level (e.g., small volume flush to a waste tank), the following items shall be performed to ensure flush completion:

- Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

- Confirm the level change in the sending vessel is consistent with the derived flush volume.

Piping branches off of the Transfer Path which did not have direct transfer flow through them (e.g., piping dead legs) are not required to have direct flush flow through them during flushing requirements. See Section 5.5.4.2.21 of the DSA for justification.

Implementation Items:

1. ESP SLUDGE SLURRY shall only be transferred along the leak-checked paths shown in DSA Chapter 3, Figure 3.7-1.

2. Within 30 days of completing ESP SLUDGE SLURRY transfers, a three line volume flush of the core pipe shall be performed. Flushing is not required if the time between transfers is less than 30 days (the 30-day completion time for the flush shall be based on completion of the last transfer).

3. Implement the requirements identified by the evaluation by performing either item a or items b.1 and b.2 below:

   a. During the performance of a transfer line flush associated with an ESP SLUDGE SLURRY transfer, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level/volume increase in the receipt vessel consistent with the derived flush volume.

   OR

   b.1. During the performance of a transfer line flush associated with an ESP SLUDGE SLURRY transfer, assurance that the flush water is being routed to the appropriate TRANSFER PATH shall be achieved through positive confirmation of a level/volume decrease in the sending vessel consistent with the derived flush volume.

   AND

   b.2. Initial flush water valve position verification can be performed using the respective flush water system's alignment checklist. Subsequent flush water valve positioning is controlled in accordance with the corresponding procedure. Flush water valve(s) in the defined TRANSFER PATH shall be independently verified.

4.18 PUMP TANK SPACE FOR CANYON TRANSFERS (DSA SECTION 3.4.2.18.1)

ATTRIBUTE REQUIREMENT: DSA Section 3.4.2.18.1.8

The receipt pump tank for an in-progress Canyon transfer can receive the entire transfer volume without overflowing the pump tank.

> DSA Section 3.4.2.18.1 Seismic Event for the transfer error scenario assumed that the receipt pump tank from the Canyon transfer could receive the entire transfer volume without overflowing the pump tank. This assumption shall be protected.

IMPLEMENTATION:

Normally Canyon transfers are received as a batch transfers into pump tanks. Prior to accepting the transfer from the Canyon, the operator shall verify that the transfer volume will be less than pump tank available volume. However, if the Canyon transfer is a continuous transfer and if the transfer pump stops or fails to start during the transfer, the operator shall notify the Canyon operator to stop the transfer. Based on the Canyon header operating level and the Canyon transfers being gravity drained (open channel flow), the drain back volume from the Canyon transfer lines will be less than the volume needed to overflow the pump tank if the Canyon transfer is stopped immediately after the pump failure.

Implementation Items:

1. If the Canyon transfer is a batch transfer, verify that the amount of waste to be received will not overflow the pump tank prior to the transfer.

2. If the Canyon transfer is a continuous transfer and if the pump tank pump stops or fails to start during the transfer, shutdown the transfer from the Canyon immediately.

4.19 PUMP TANK TRANSFER JET CONTROL (TSR 5.8.2.36) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.36 & DSA Section 5.5.4.2.36.2

Controls shall be established to ensure that steam/air is manually isolated from pump tank transfer jets when not transferring. Proper valve line-up of the jet transfer discharge path will be performed via the Transfer Control Program.

> The amount of airborne material at any location containing liquid waste is related to the conditions of the waste (e.g., waste temperature, surface area, ventilation flow, and available vapor volume). In addition, anticipated normal operations and process upsets could disturb liquid waste and cause an increase in the airborne component of wastes in the CSTF. Some waste disturbances (e.g., normal waste transfers) can cause minor waste splashing but do not result in a significant increase in airborne material and are not considered accidents, as documented in the Hazard Analysis. Other intended and unintended waste disturbances (e.g., agitation, sparging, stripping) could result in a more significant airborne material release due to increased splashing or spraying.
>
> Various equipment used to transfer and agitate the waste uses high-pressure steam and/or air sources. It is possible as a result of equipment malfunction or a break in a steam or air line that high-pressure steam or air will impinge on the liquid waste and generate aerosols. Most of the aerosolization events involve liquid jet impingement, steam jet impingement or air jet impingement. Pump tank aerosolization events due to transfer jet impingement are prevented by isolating the pump tank transfer jet when not in use and jet discharge path valve position independent verification when the jet is in use.

IMPLEMENTATION:

This administrative control is credited as a Safety Class control to prevent pump tank aerosolization event. In the Tank Farms, FPT-2, FPT-3, HPT-2, HPT-3, HPT-4, HPT-5, HPT-6, HPT-8, HPT-9 and HPT-10 are equipped with steam jets. A manual valve between the steam/air supply and the transfer jet for each pump tank will be identified as the isolation valve to prevent steam/air entering the pump tank when not using the jet for transfer. The isolation valve will be closed upon completion of the transfer. Also, whenever these identified valves have been manipulated for other reasons (e.g., maintenance, surveillance), an alternate valve(s) shall be closed prior to the manipulation of the identified valve. Jet discharge path valve position verification prior to the transfer will be performed per Section 4.5 of this PDD.

Implementation Items:

1. Ensure that the pump tank transfer jet gang valve discharge isolation valve is closed after the transfer completion.

2. Ensure that the pump tank transfer jet gang valve discharge isolation valve is independently verified in the closed position.

3. Ensure alternate valve(s) is closed and Independently Verified prior to manipulation of the pump tank transfer jet gang valve discharge isolation valve for other activities which require manipulation of the valve. The alternate valve(s) shall isolate both steam and air supplies to the jet.

4.20 HYDROGEN GENERATION RATE CONTROL (TSR 5.8.2.31) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.31 & DSA Section 3.4.1.5.5

Controls shall be established to ensure that the hydrogen generation rates for waste in the facility are within the bounding values used in the safety analysis for the applicable locations.

> DSA Section 3.4.1.5.5 listed the hydrogen generation rates used in the various accident events and residual calculations. The controls shall ensure that transferring materials are within these hydrogen generation rates to protect the assumptions.

IMPLEMENTATION:

Transferring waste from tank to tank, adding a large quantity of water to a waste tank, and removing supernate from a waste tank could change the hydrogen generation rate. An evaluation shall be performed prior to these activities to ensure that the hydrogen generation rates are within the assumed values. Evaporator bottoms hydrogen generation requirements are addressed in Evaporator Feed Qualification Program Description Document (Reference 10). *Note the bounding hydrogen generation rate for the 242-25H evaporator was updated per Reference 35.* Hydrogen generation rates shall be obtained from WCS.

Implementation Items:

1. Verify that sludge slurry material radiolytic hydrogen generation rate is less than or equal to 1.5E-5 ft^3/gal-hr prior to the transfer and document in the waste transfer evaluation and approval procedure.

2. Verify that supernate material hydrogen generation rate is less than or equal to 9.6E-6 ft^3/gal-hr prior to the transfer and document in the waste transfer evaluation and approval procedure.

3. Deleted.

4. Verify that the hydrogen generation rate of the material transferring through Type I and Type II Tanks annuli is less than or equal to 5.6E-6 ft^3/gal-hr prior to the transfer and document in the waste transfer evaluation and approval procedure.

5. Deleted.

6. Verify that ESP SLUDGE SLURRY material hydrogen generation rate is less than or equal to 5.0E-5 ft^3/gal-hr prior to the transfer and document in the waste transfer evaluation and approval procedure.

4.21 ARM LOCATION PROGRAM (TSR 5.8.2.41)

ATTRIBUTE REQUIREMENT: 5.8.2.41

Programmatic controls shall be implemented prior to HIGH-REM WASTE TRANSFERS and EMD STP operation to ensure the placement of ARMs for above-ground waste transfer lines (including excavated transfer lines) for radiological release detection purposes. The program shall also determine the alarm requirements (e.g., control room alarm or local alarm and operator/control room two-way communication) for each ARM. The ARMs shall comply with LCO 3.7.9 during HIGH-REM WASTE TRANSFERS through above-ground waste transfer lines and LCO 3.8.11 during EMD STP operations.

> DSA Section 3.4.2.9 accident analysis credits ARMs for all above-ground leak locations (including excavation locations) during HIGH-REM WASTE TRANSFERS and EMD STP operation. The detection capability of the ARM devices is sensitive to the radionuclide distribution. Therefore, an evaluation shall be performed prior to HIGH-REM WASTE TRANSFERS and EMD STP operation to determine the proper placement of the ARMs to ensure that they can perform their intended safety function. The program shall consider appropriate transfer specific parameters (e.g., Cs-137 concentration, shielding obstructions between leak locations and monitoring locations) when determining ARM placement. The program shall also determine the alarm requirements (control room alarm or local alarm and operator/control room two-way communication) for each ARM. The ARMs shall comply with LCO 3.7.9 and 3.8.11. LCO 3.7.9 is applicable to above-ground transfer lines in the TRANSFER PATH during HIGH-REM WASTE TRANSFERS. Above-ground transfer lines include those transfer lines designed to be permanently above-ground, and transfer lines that are temporarily exposed due to excavations. LCO 3.8.11 is applicable to EMD STP operations.

IMPLEMENTATION:

An evaluation shall be performed prior to HIGH-REM WASTE TRANSFERS to identify the ARM locations for above-ground transfer lines and exposed transfer lines in excavations. The evaluation shall be performed per the approved methodology in Reference 26.

Implementation Items:

1. For HIGH-REM WASTE TRANSFERS, perform an evaluation to identify ARM locations and alarm requirements for above-ground transfer lines and exposed transfer lines in the excavations in the TRANSFER PATH per Reference 26.

2. Perform an evaluation to identify ARM locations and alarm requirements for operating EMD STPs per Reference 14.

3. Ensure that the ARM locations and alarm requirements identified by the evaluation in items 1& 2 are included in the transfer procedure. The identified ARMs shall comply with LCO 3.7.9 and 3.8.11 requirements.

4.22 INHALATION DOSE POTENTIAL CONTROL (TSR 5.8.2.51) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.51

Controls shall be established to ensure that the inhalation dose potentials (accounting for analytical uncertainty as described in DSA Chapter 5) are within the values analyzed in the DSA.

DSA Section 3.4.1.5.1 source term inputs and assumptions listed several waste streams that are used throughout the DSA to signify the Material At Risk (MAR) per unit volume basis. This section listed Bounding Sludge Slurry waste stream inhalation dose potential as up to 1.5E+09 rem/gal and Slurried Type IV Tank Waste stream inhalation dose potential as up to 1.0E+07 rem/gal (including 2 Sigma uncertainty). If the limits are met by programs (or their defining aspects) and do not require sample results, then analytical uncertainty is not applicable.

IDP uncertainty can be calculated based on isotopic concentration measurement uncertainty only since uncertainties associated with physical property data (e.g. mass, density) are very small in comparison to isotopic concentration uncertainties and can be ignored without significant impact on the overall uncertainty (reference 32). Also, analytical uncertainty would not be applicable for concentrations reported at Minimum Detectable Levels (MDL), as there is at least a 95% confidence that the result is below this value.

Reference 5 documented that none of the H-Area waste tanks exceeded the Bounding Sludge Slurry inhalation dose potential based on current tank status. However, it demonstrated that for tanks where the sludge mass exceeds 4.36E+04 kg and the sludge dose potential exceeds 9.0E+05 rem/gram, the resultant slurry may exceed the analyzed inhalation dose potential of 1.5E+09 rem/gal. Therefore, prior to initiating sludge mixing activities within tanks meeting this criteria, an evaluation shall be performed to verify that the resultant slurry will not exceed inhalation dose potential of 1.5E+09 rem/gal. This administrative control is applicable only when slurrying H-Area sludge tanks.

Also Reference 6 documented that of all the Type IV tanks, only Tanks 21 and 22 have the potential to exceed the analyzed inhalation dose potential for Type IV tank slurry of 1.0E+07 rem/gal (including 2 Sigma uncertainty when using sample results). Therefore, prior to initiating sludge mixing activities within Tank 21 or Tank 22, an evaluation shall be performed to verify that the resultant slurry will not exceed an inhalation dose potential of 1.0E+07 rem/gal. This evaluation will be performed outside the WCS. Therefore, uncertainty will be included in the evaluation and WCS limit will not be changed.

This administrative control is applicable only when slurrying H-Area sludge tanks.

The inhalation dose potential of waste material in Tank 50, Tank 50 Valve Box, and the receipt transfer lines into Tank 50 shall contain no more than the bounding Tank 50

Supernate inhalation dose potential of 2.09E+05 rem/gal. Remaining within these limits also protects the inhalation dose potential assumptions in the Saltstone Facility WAC for transfer receipts from the CSTF.

The inhalation dose potential of waste transferred to the 242-16H evaporator shall be less than or equal to 3.3E+07 rem/gal to protect the analyzed consequences. Ensuring that sludge solids carryover does not occur (maximum 1 wt. % sludge) as accomplished by TSR AC 5.8.2.19 ensures compliance with the 242-16H evaporator feed/bottoms inhalation dose potential; therefore, no additional implementation items are required in this PDD.

As discussed in DSA Addendum Section 3.3 [Ref. 35], the 242-25H Evaporators Bottoms waste stream (and associated feed streams) inhalation dose potential limit has been updated to 1.85E+07 rem/gal. Based on this change to the waste stream definition, protecting 1 wt.% sludge solids (via the Sludge Carryover Minimization Program) does not necessarily ensure compliance with the revised 242-25H Evaporator Bottoms (and associated feed) inhalation dose potential limit of 1.85E+07 rem/gal (this value does not include uncertainty). Therefore, an engineering evaluation will be required to ensure compliance with the inhalation dose potential limit for 242-25H Evaporator Bottoms (and associated feed).

The inhalation dose potential of waste transferred to the 241-96H ARP Facility shall be less than or equal to 1.4E+06 rem/gal to protect the analyzed consequences of the facility. This is protected by salt macro batch qualification in Tank 49. Therefore, all downstream processing facilities inhalation dose potential limits are protected and no additional implementation items are required in this PDD.

The inhalation dose potential of waste transferred to the TCCR Unit shall be less than or equal to 1.4E+06 rem/gal to protect the analyzed consequences.

This attribute is also applicable to TCCR TRANSFERS.

<u>IMPLEMENTATION</u>:

An evaluation shall be performed to verify that the inhalation dose potential does not exceed the Bounding Sludge Slurry inhalation dose potential of 1.5E+09 rem/gal when the sludge mass exceeds 4.36E+04 kg AND sludge dose potential exceeds 9.0E+05 rem/gram prior to initiating the sludge mixing (Reference 5). Prior to initiating the sludge mixing in Tanks 21 and 22, an evaluation shall be performed to verify that the slurry inhalation dose potential does not exceed the Type IV tank slurry inhalation dose potential or 1.0E+07 rem/gal (Reference 6).

Prior to transferring waste to Tank 50, Tank 50 Valve Box, or the receipt transfer lines into Tank 50, an evaluation shall be performed to verify that the inhalation dose potential will not exceed 2.09E+05 rem/gal.

If 1 wt.% sludge solids carryover will protect the associated limit for 242-25H Evaporator Bottoms and feed (as determined by engineering evaluation), then the Sludge Carryover Minimization (SCOM) Program requirements may be used for protecting the sludge solids

content and inhalation dose potential. However, if the engineering evaluation requires less than 1 wt.% sludge solids for meeting the inhalation dose potential limit, then additional requirements (as determined by the engineering evaluation) shall be implemented [Reference 35].

Implementation Items:

1. Prior to initiating sludge mixing activities in a H-Area waste tank, determine if sludge mass AND the sludge dose potential is greater than 4.36E+04 kg AND 9.0E+05 rem/gram respectively.

2. If sludge mass AND the sludge dose potential is greater than 4.36E+04 kg AND 9.0E+05 rem/gram respectively, perform an evaluation to verify that the resultant inhalation dose potential will not exceed 1.5E+09 rem/gal prior to initiating the sludge mixing in the tank.

3. Prior to initiating sludge mixing activities in Tanks 21 and 22, perform an evaluation to verify that resultant inhalation dose potential will not exceed 1.0E+07 rem/gal (including 2 Sigma uncertainty).

4. Prior to transferring waste to Tank 50, Tank 50 Valve Box, or the receipt transfer lines into Tank 50, perform an evaluation to verify the inhalation dose potential will not exceed 2.09E+05 rem/gal.

5. Requirements for IDP for 3H Evaporator System tanks are described in SCOM PDD (Reference 36)

6. The waste transfer inhalation dose potential must be verified to be less than or equal to 1.4E+06 rem/gal (including 2 Sigma uncertainty) prior to initiating waste transfers to the TCCR Unit.

4.23 WASTE ACCEPTANCE CRITERIA PROGRAM (TSR 5.8.2.15) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.15

The Waste Acceptance Criteria Program shall ensure that the composition of waste streams received into the FACILITY is within analyzed limits. Transfer of waste from CST Facilities to other facilities shall meet the receiving facility Safety Basis.

IMPLEMENTATION:

The Waste Acceptance Criteria (WAC) and Waste Compliance Plan (WCP) programs as outlined in Reference 15 shall be used to meet this requirement. When sample results are utilized to demonstrate compliance with a limit/requirement, an analytical uncertainty of 2 Sigma shall be included prior to comparing to the limit/requirement. This is applicable to the following limits/requirements: inhalation dose potential, fissile material, organic contribution to flammable vapors, and Hazard Categorization for MCU.

IDP uncertainty can be calculated based on isotopic concentration measurement uncertainty only since uncertainties associated with physical property data (e.g. mass, density) are very small in comparison to isotopic concentration uncertainties and can be ignored without significant impact on the overall uncertainty (reference 32). Also, analytical uncertainty would not be applicable for concentrations reported at Minimum Detectable Levels (MDL), as there is at least a 95% confidence that the result is below this value.

The ERD shall list the approved waste streams that can be received into the FACILITY based on WAC and WCP programs.

Implementation Items:

1. List all approved waste streams from non CSTF facilities in the ERD (Reference 20).

4.24 TRANSFERS FROM WASTE TANK ANNULI (TSR 5.8.2.23) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.23 & DSA Section 5.5.4.2.23

An annulus transfer program shall be established governing WASTE TRANSFERS from waste tank annuli. This program shall include, as a minimum, the installation and operation of a negative pressure ventilation system with HEPA filtration prior to TRANSFER INITIATION of waste from an annulus via a jetted transfer (steam or air). For tanks with a negative pressure annulus, this SAC ensures that, prior to transferring waste from the waste tank annulus via a jetted transfer (steam or air), the annulus ventilation system with HEPA filter is operating.

The Contingency Transfer System provides an alternate means to remove accumulated waste from the annulus of a leaking waste tank and transfer the waste back to the primary side of the same waste tank. Each Contingency Transfer System is comprised of a portable submersible pump/motor assembly; therefore, (since a jet is not utilized) this administrative control does not apply to CONTINGENCY TRANSFERS.

Implementation Items:

1. Ensure that negative pressure ventilation system with operable, tested HEPA filtration and calibrated differential pressure instrumentation is online while transferring annulus contents via a jetted transfer (steam or air).

2. For tanks with a negative pressure annulus, ensure that, prior to transferring waste from the waste tank annulus via a jetted transfer (steam or air), the annulus ventilation system with operable, tested HEPA filter and calibrated differential pressure instrumentation is operating.

4.25 PUMP TANK BACKUP VENTILATION SYSTEM SYSTEMS PROGRAM (TSR 5.8.2.37) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.37

Prior to TRANSFER INITIATION, backup portable ventilation with portable generator shall be installed and functional for pump tanks which are receiving steam jetted transfers from a source of greater than 1200 gallons (excluding HDB-8 Complex pump tanks and pump tanks receiving canyon transfers). These systems shall be tested and maintained to ensure they can perform their safety function when required. If the backup portable ventilation system becomes non-functional while the pump tank is receiving a transfer, then the transfer shall be terminated immediately.

IMPLEMENTATION:

Backup portable ventilation systems are installed and tested for functionality prior to performing the transfer. They are removed at the completion of the transfer evolution and returned to storage for future use. No additional maintenance requirements apply since these systems are not left in place and are tested for functionality at each installation.

Implementation Items:

1. Backup portable ventilation with portable generator shall be installed and functional for pump tanks which are receiving steam jetted transfers from a source with an inventory greater than 1200 gallons (excluding HDB-8 Complex pump tanks and pump tank receiving canyon transfers).

2. If the backup portable ventilation system becomes non-functional while the pump tank is receiving a transfer, then the transfer shall be terminated immediately.

3. Normal power may be utilized with the portable ventilation system; however, the portable generator shall be installed and functional.

4.26 DSA SECTION 3.4.2.9.3

ATTRIBUTE REQUIREMENT: DSA Section 3.4.2.9.3

The source term analysis described in DSA Section 3.4.2.9.3 assumed that the secondary containments are closed (i.e., cell covers are in place, but small openings such as access or inspection ports may be open) when a WASTE TRANSFER is in progress through the secondary containment. Secondary containments that have liquid drain/overflow communication (at equivalent level of less than 15,000 gallons) from the secondary containment involved with the WASTE TRANSFER, shall also be closed (i.e., cell covers are in place, but small openings such as access or inspection ports may be open).

IMPLEMENTATION:

Secondary containments are typically underground or partially underground reinforced concrete vaults lined with stainless steel. They are covered with a removable concrete lid or stainless steel cover, which is generally in place but can be removed for maintenance activities requiring cell entry. Secondary containments include the following process areas:

- Diversion Boxes (DBs)
- Pump Pits (PPs)
- Valve Boxes (VBs)
- High Point Flush Pit (HPFP)
- LDB Drain Cell
- Evaporator Cells

Some of the secondary containments drain or overflow to another secondary containment. If the secondary containment in the TRANSFER PATH is not capable of holding 15,000 gallons before it drains or overflows into another one, cell covers for all secondary containments that have the potential to receive the drain or overflow shall also be covered.

From reference 29, the following secondary containments either drain or overflow before holding 15,000 gallons:

FDB-3 drains to FDB-2 which drains to FPP-1

FDB-4 drains to FPP-2

HDB-2 drains to HPP-3

HDB-8 overflows to HPP-7, 8, 9, 10 through pipe chaseVB-1 through 4 drains to VB-5 which drains to MLDB-5 @ FDB-2 which overflows to FPP-1

HPFP drains to LDB-1A and LDB-2A @ FDB-2 which drain and overflows to FPP-1

Also, the following Waste Tanks in the East Hill drain to LDB Drain Cell:

Tank 49 VB drains to LDB Drain Cell

Tank 51 LDBs over flows to LDB Drain Cells

Even though Tank 48 VB drains to LDB Drain Cell, cell covers are not required since transfers in and out of Tank 48 are prohibited.

Even though Tank 50 VB drains to LDB Drain Cell, cell covers are not required since transfers in and out of Tank 50 are non-waste transfers.

All other secondary containments do not drain or overflow to another secondary containment.

Implementation Items:

1. Transfer procedures shall verify that secondary containment covers for Pump Pits, High Point Flush Pit, LDB Drain Cell, Valve Boxes, Evaporator Cells (except for evaporator cell sump jet transfers), and Diversion Boxes are in place for all the secondary containments in the TRANSFER PATH prior to the WASTE TRANSFER. Secondary containment covers are not required for the secondary containments downstream of the first sound isolation point.

2. If FDB-3 is in the TRANSFER PATH, transfer procedures shall verify that FDB-2 and FPP-1 covers are in place prior to the WASTE TRANSFER.

3. If FDB-2 is in the TRANSFER PATH, transfer procedures shall verify that FPP-1 covers are in place prior to the WASTE TRANSFER.

4. If FDB-4 is in the TRANSFER PATH, transfer procedures shall verify that FPP-2 covers are in place prior to the WASTE TRANSFER.

5. If HDB-2 is in the TRANSFER PATH, transfer procedures shall verify that HPP-3 covers are in place prior to the WASTE TRANSFER.

6. If HDB-8 is in the TRANSFER PATH, transfer procedures shall verify that HPP-7, 8, 9, and 10 covers are in place prior to the WASTE TRANSFER.

7. If VB-1through 4 is in the TRANSFER PATH, transfer procedures shall verify that VB-5, FDB-2 and FPP-1 covers are in place prior to the WASTE TRANSFER.

8. Deleted

9. If HPFP is in the TRANSFER PATH, transfer procedures shall verify that FDB-2 and FPP-1 covers are in place or HPFP drain plugs are installed prior to the WASTE TRANSFER.

10. If LDB Drain Cell is in the TRANSFER PATH for transfers in and out of Tanks 49 and 51, transfer procedures shall verify that LDB Drain Cell cover is in place prior to the WASTE TRANSFER.

4.27 242-16H EVAPORATOR CHEMICAL CLEANING (TSR 5.8.2.52) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.52 & DSA Section 5.5.4.2.49

The following controls shall be implemented during chemical cleaning of the 242-16H Evaporator:

1. Prior to adding acid to the evaporator vessel and while the vessel contains acidic material (i.e., pH less than 7.0), double valve isolation shall be established between the evaporator vessel and the evaporator drop tank.

   Transfers out of the evaporator vessel shall be permitted only when the pH is greater or equal to than 7.0. The pH may be considered greater than or equal to 7.0 when adequate caustic addition and mixing have occurred, or verified by sampling.

2. Prior to TRANSFER INITIATION from the Evaporator cell sump to Tank 43, the cell sump contents shall be verified, via sampling, to have a pH greater than or equal to 7.0.

   This SAC is to ensure that acidic material, used during the chemical cleaning process of the 242-16H Evaporator, is not added to a waste tank and cause potential degradation of the waste tank or cooling coils, or cause an increase in hydrogen generation rate.

IMPLEMENTATION:

Independent verification is required for the double valve isolation stated in Item 1 above.

Implementation Items:

1. Prior to adding acid to the evaporator vessel and while the vessel contains acidic material, double valve isolation shall be established between the evaporator vessel and the evaporator drop tank. Independent verification is required for this double valve isolation.

2 Transfers out of the evaporator vessel shall be permitted only when the pH is greater or equal to than 7.0. The pH may be considered greater than or equal to 7.0 when adequate caustic addition and mixing have occur.

ed, or verified by sampling.

3 Prior to TRANSFER INITIATION from the Evaporator cell sump to Tank 43, the cell sump contents shall be verified, via sampling, to have a pH greater than or equal to 7.0 during Chemical Cleaning only.

4.28 WASTE TANK CHEMICAL CLEANING PROGRAM (TSR 5.8.2.53) (SAC AS NOTED)

ATTRIBUTE REQUIREMENT: 5.8.2.53.a,b,c,d,e,f,g,h,i,j,k

In addition to the Transfer Control Program, the following controls shall be implemented during operations associated with waste tanks in ACIDIC CHEMICAL CLEANING MODE and CHEMICAL CLEANING TRANSFERS:

The TRANSFER PATH for CHEMICAL CLEANING TRANSFERS (or related vent/drain operations) shall only be permitted through the following LEAK DETECTION LOCATIONS: FDB-2, FDB-3, FDB-4, HDB-2, HDB-7, Valve Boxes 1 through 5, Valve Box LDB-17, Tank 51 Valve Box, Tank 51 Drain Valve Box, FPP-1, FPP-2, and HPP-3. CHEMICAL CLEANING TRANSFERS that may leak from primary containment to the H-Area Catch Tank and LDB Drain Cell have also been analyzed (TRANSFER PATHS associated with these locations are permitted to have CHEMICAL CLEANING TRANSFERS) (SAC).

Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), isolation (single leak-tested valve, double valve isolation or blank) shall be established to preclude CHEMICAL CLEANING TRANSFERS from entering pump tanks, waste tanks, or transfer facilities outside of the intended TRANSFER PATH (SAC).

During CHEMICAL CLEANING TRANSFERS, acidic waste material from the vent and drain operation shall only be permitted to FPT-1, HPT-3 and the waste tanks associated with the vent/drain path. (SAC)

Prior to TRANSFER INITIATION of transfer line vent and drain operation associated with a CHEMICAL CLEANING TRANSFER, verification shall be performed to ensure that sufficient inhibitors are present in the applicable pump tank (FPT-1, HPT-3) to ensure neutralization of the acidic waste. (SAC)

Within 60 days after initiation of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), perform one of the following for each Valve Box, DB, PP, LDB Drain Cell, or H-Area Catch Tank that was associated with a CHEMICAL CLEANING TRANSFER (after completion of the transfer line flushing operation):

- Verify no level increase has occurred in the applicable transfer facility.
- Verify the material contained in the applicable transfer facility is non-acidic (i.e, pH greater than or equal to 7).
- Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7).

Prior to TRANSFER INITIATION from a Valve Box, DB, PP, the LDB Drain Cell, or the H-Area Catch Tank that was associated with a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), perform one of the following for the applicable transfer facility: (SAC)

- Verify the material contained in the applicable transfer facility is non-acidic (i.e., pH greater than or equal to 7).
- Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7).

This control shall apply to a transfer facility (e.g., sump) transfers as a result of level increase from the time of TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations) through the applicable transfer facility until the previous item above is complete.

Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER from a waste tank in ACIDIC CHEMICAL CLEANING MODE, an engineering evaluation (accounting for waste tank mixing device operation to ensure adequate mixing of contents) shall be performed to ensure the oxalic acid content in the waste tank is less than or equal to 4 wt.%.

Prior to waste tank mixing device operation in waste tanks in ACIDIC CHEMICAL CLEANING MODE, verification shall be performed to ensure that sufficient water has been added to the waste tank to ensure the oxalic acid content in the waste tank (once mixed) will be less than or equal to 4 wt. %. (SAC)

Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), verification shall be performed to ensure that sufficient inhibitors are present in the applicable receipt waste tank to ensure neutralization of the acidic waste. (SAC)

During receipt of CHEMICAL CLEANING TRANSFERS (or related vent/drain operations), at least one waste tank mixing device shall be operating in the applicable receipt waste tank to ensure adequate mixing and neutralization of the acidic waste. (SAC)

During receipt of CHEMICAL CLEANING TRANSFERS, acidic waste shall enter the receipt tank via a flow path that is below the waste tank liquid level. (SAC)

<u>IMPLEMENTATION</u>:

A CHEMICAL CLEANING TRANSFER is a transfer containing oxalic acid that occurs as a part of the waste tank chemical cleaning process. CHEMICAL CLEANING TRANSFERS shall be considered WASTE TRANSFERS. Venting and draining of transfer lines associated with a CHEMICAL CLEANING TRANSFER, provided there is no potential to siphon waste, are not considered as a CHEMICAL CLEANING TRANSFER or a WASTE TRANSFER. Once a transfer line has been flushed, subsequent transfers need not be considered as a CHEMICAL CLEANING TRANSFER.

The following transfer facilities have been analyzed to support CHEMICAL CLEANING TRANSFERS and may be on the TRANSFER PATH or serve as a LEAK DETECTION

LOCATION, as applicable: FDB-2, FDB-3, FDB-4, HDB-2, HDB-7, Valve Boxes 1 through 5, Valve Box LDB-17, Tank 51 Valve Box, Tank 51 Drain Valve Box, FPP-1, FPP-2, HPP-3, the H-Area Catch Tank and the LDB Drain Cell.

Waste Tanks 7, 13, and 51 are the chemical cleaning receipt waste tanks.

The following controls are applicable to all Type I/II Waste Tanks except Tank 1, chemical cleaning operations. Waste Tank 1 is prohibited from chemical cleaning operations.

Prior to initiation of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), isolation (i.e., double valve, single valve leak-tested, blank) shall be established to preclude CHEMICAL CLEANING TRANSFERS from entering pump tanks, waste tanks, or other transfer facilities outside of the intended TRANSFER PATH. Independent Verification of the TRANSFER PATH alignment shall be performed.

Vent and drain of acidic material from CHEMICAL CLEANING TRANSFERS shall only be permitted into FPT-1, HPT-3, and the waste tanks associated with the vent/drain path.

Engineering evaluation is required prior to initiation of a CHEMICAL CLEANING TRANSFER to ensure sufficient inhibitors are present in the applicable pump tank (FPT-1, HPT-3) to neutralize spent acid drainback from the transfers. Independent Verification of this attribute is performed via verification/checking per E7 Manual requirements.

Prior to TRANSFER INITIATION of transfer line vent and drain operation associated with CHEMICAL CLEANING TRANSFER, verification shall be performed to ensure that sufficient inhibitors are present in the applicable pump tank (FPT-1, HPT-3) to ensure neutralization of the waste. If inhibitors must be added to the pump tank as described in the previous paragraph and the value determined by the engineering evaluation must be transposed into the governing procedure, Independent Verification of the transposed value shall be performed. If this value is directly defined in the procedure, the Independent Verification of the value is accomplished by the standard procedure revision and approval process. Additionally, the inhibitor volume actually added to the pump tank shall be Independently Verified. Finally, Independent Verification of the inhibitor addition flow path shall be performed.

Upon completion of a CHEMICAL CLEANING TRANSFER, an IW flush of the TRANSFER PATH core pipe shall be performed. This flush will be performed in conjunction with any flush required by Section 4.13, “Flushing the core pipe after WASTE TRANSFERS”. This requirement also supports the required flush after a CHEMICAL CLEANING TRANFER contained in the CSTF Corrosion Control Program, WSRC-TR-2002-00327.

Within 60 days after a CHEMICAL CLEANING TRANSFER has been initiated, the following activities must occur for each Valve Box, DB, PP, LDB Drain Cell or H-Area Catch Tank that was associated with the CHEMICAL CLEANING TRANSFER:

- CHEMICAL CLEANING TRANSFER (or related vent/drain operation) has been completed,

  AND

- The TRANSFER PATH of the CHEMICAL CLEANING TRANSFER has been flushed with IW,

  AND

- one of the following has been performed:

  - Verify no level increase has occurred in the applicable transfer facility,

    OR

  - Verify the material contained in the applicable transfer facility is non-acidic (i.e., pH greater than or equal to 7),

    OR

  - Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7). An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization.

Laboratory analysis or litmus paper test can be used to verify pH.

Prior to TRANSFER INITIATION from a Valve Box, DB, PP, LDB Drain Cell, or H-Area Catch Tank that was associated with a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), perform one of the following for the applicable transfer facility. This requirement shall apply to the transfer facility transfers as a result of level increase from the time of TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations) through the applicable transfer facility until the previous item above is complete:

- Verify the material contained in the applicable transfer facility is non-acidic (i.e., pH greater than or equal to 7),

  OR

- Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7). An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization.

Laboratory analysis can be used to verify pH of the material. If this method is chosen, the sample results shall be independently reviewed, i.e., the laboratory sample analysis value shall be confirmed to be greater than or equal to pH 7 by a second person. Litmus paper testing can also be used to verify pH. This method requires Independent Verification of the result, i.e., the litmus paper must be verified by a second person to be indicative of greater than or equal to pH 7.

If inhibitors must be added to the transfer facility and the value determined by the engineering evaluation must be transposed into the governing procedure, Independent Verification of the transposed value shall be performed. If this value is directly defined in the procedure, the Independent Verification of the value is accomplished by the standard procedure revision and

approval process. Additionally, the inhibitor volume actually added to the transfer facility shall be Independently Verified. Independent Verification of the engineering evaluation is performed via verification/checking per E7 Manual requirements.

Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER from a waste tank in ACIDIC CHEMICAL CLEANING MODE, an engineering evaluation shall be performed to ensure the OA contents in the waste tank is less than or equal to 4 wt.%. This can be established by tracking the cumulative number of gallons of 8 wt. % OA added to the treatment tank and by adding at least that many gallons of WW or IW, adjusted for specific gravity, to the tank. Per reference 31, when a pump is operating at the rated design speeds, mixing times are calculated to be short (<1 hour) for Newtonian fluids such as water. Therefore, mixing device shall be operating a minimum of 1 hour prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER. This protects the input that corrosion induced hydrogen generation does not contribute to the flammable vapor concentrations in transfer facilities.

Prior to waste tank mixing device operation in waste tanks in ACIDIC CHEMICAL CLEANING MODE, verification shall be performed to ensure that sufficient water has been added to the waste tank to ensure the oxalic acid content in the waste tank (once mixed) will be less than or equal to 4 wt. %. This can be established by tracking the number of gallons of 8 wt. % OA added to the treatment tank and by adding at least that many gallons of WW or IW, adjusted for specific gravity, to the tank. IV is required for the following items:

1. Each OA tanker volume addition and for the total (cumulative) amount of OA added for determining the amount of dilution water.

2. Volume of dilution water needed.

3. Volume of dilution water actually added.

4. Dilution water source line up, if a totalizer is used for volume determination.

Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations) verification shall be performed to ensure that sufficient inhibitors are present in the applicable receipt waste tank to ensure neutralize of the acidic waste. An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization in the waste tank.

If inhibitors must be added to the transfer facility and the value determined by the engineering evaluation must be transposed into the governing procedure, Independent Verification of the transposed value shall be performed. If this value is directly defined in the procedure, the Independent Verification of the value is accomplished by the standard procedure revision and approval process. Additionally, the inhibitor volume actually added to the pump tank shall be Independently Verified. Independent Verification of the engineering evaluation is performed via verification/checking per E7 Manual requirements.

During receipt of CHEMICAL CLEANING TRANSFERS (or related vent/drain operations), at least one mixing device shall be operating in the applicable receipt waste tank. Per reference 30, tests demonstrated that short periods of moderate energy mixing were sufficient to blend the

liquid layers and raise the pH of the solution near the surface. Prior to TRANSFER INITIATION, transfer procedure shall Independently Verify that at least one mixing device is operating in the receipt tank. Additionally, the transfer procedure shall require shut down the transfer if it is found that at least one receipt waste tank mixing device is not operating during the transfer.

During receipt of CHEMICAL CLEANING TRANSFERS, acidic waste shall enter the receipt tank via a flow path below the waste tank liquid level. This will preclude splashing of acidic material on to carbon steel components in the receipt waste tank. Prior to TRANSFER INITIATION, transfer procedure shall Independently Verify (IV) the waste transfer line-up to ensure that the acidic waste will enter via a flow path below the waste tank liquid level. Post transfer vent and drain operations into Tank 51 (i.e., for the transfer line low point located south of Tank 51) are permitted to receive acidic waste above the liquid level due to limited volume.

DSA Section 3.4.2.12, states that transfer leak initiated Waste Tank Annulus Explosion scenario associated with Type I/II Waste Tanks undergoing Chemical Cleaning is not a credible event, since Type I/II Waste Tank Cleaning transfers that traverse the annulus of a Type I/II Waste Tank are prohibited. It also states that Tank 51 (receipt tank) transfer line that traverses the annulus is only used for vent/drain operation following Type I/II Waste Tank Chemical Cleaning transfers. Based on the small drain volume (<50 gallons), and the robustness of this transfer line segment (stainless steel core pipe and carbon steel jacket), a Tank 51 Annulus Explosion due to Chemical Cleaning transfer receipt is not credible. Therefore, vent and drain operations associated with Chemical Cleaning Transfers are permitted in the transfer line that traverses the Tank 51 annulus.

Implementation Items:

1. TRANSFER PATH for CHEMICAL CLEANING TRANSFERS, and vent and drain operations associated with CHEMICAL CLEANING TRANSFERS shall only be permitted through FDB-2, FDB-3, FDB-4, HDB-2, HDB-7, Valve Boxes 1 through 5, and Valve Box LDB-17, Tank 51 Valve Box, Tank 51 Drain Valve Box, FPP-1, FPP-2, and HPP-3. CHEMICAL CLEANING TRANSFERS that may leak from primary containment to the H-Area Catch Tank and LDB Drain Cell have also been analyzed (Transfer Paths associated with these locations are permitted to have CHEMICAL CLEANING TRANSFERS).

2. Waste Tanks 7, 13, and 51 are the allowable chemical cleaning receipt waste tanks.

3. Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER, isolation (i.e., double valve, single valve leak-tested, blank) shall be established to preclude acidic waste from entering pump tanks, waste tanks or transfer facilities outside of the intended TRANSFER PATH. Independent Verification of the TRANSFER PATH alignment shall be performed.

4. Vent and drain of acidic material from CHEMICAL CLEANING TRANSFERS shall only be permitted to FPT-1, HPT-3, and the waste tanks associated with the vent and drain path.

5. Engineering evaluation is required prior to initiation of CHEMICAL CLEANING TRANSFER to ensure sufficient inhibitors are present in the applicable pump tank (FPT-1, HPT-3) to neutralize spent acid drainback from the transfers.

6. Prior to TRANSFER INITIATION of transfer line vent and drain operations associated with CHEMICAL CLEANING TRANSFER, verification shall be performed to ensure that sufficient inhibitors are present in the applicable pump tank (FPT-1, HPT-3) to ensure neutralization of the waste.

7. If inhibitors must be added to the pump tank as described in items 5 & 6, the value determined by the engineering evaluation must be transposed into the governing procedure. Independent Verification of the transposed value shall be performed.

8. If inhibitors must be added to the pump tank as described in items 5 & 6, the inhibitor volume actually added to the pump tank shall be Independently Verified.

9. If inhibitors must be added to the pump tank as described in items 5 & 6, Independent Verification of the inhibitor addition flow path shall be performed.

10. Upon completion of a CHEMICAL CLEANING TRANSFER, an IW flush of the TRANSFER PATH core pipe shall be performed.

11. Within 60 days after initiation of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), perform one of the following for each Valve Box, DB, PP, LDB Drain Cell, or H-Area Catch Tank that was associated with a CHEMICAL CLEANING TRANSFER:

- CHEMICAL CLEANING TRANSFER (or related vent/drain operation) has been completed,

  AND

- The TRANSFER PATH of the CHEMICAL CLEANING TRANSFER has been flushed with IW,

  AND

- one of the following has been performed:

  - Verify no level increase has occurred in the applicable transfer facility,

    OR

- Verify the material contained in the applicable transfer facility is non-acidic (i.e., pH greater than or equal to 7),

  OR

- Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7). An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization.

12. Prior to TRANSFER INITIATION from a DB, PP, VB, LDB Drain Cell, or H-Area Catch Tank that was associated with a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), perform one of the following for the applicable transfer facility. This requirement shall apply to the transfer facility transfers as a result of level increase from the time of TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations) through the applicable transfer facility until item 10 above is complete:

    - Verify that the material contained in the applicable transfer facility is non-acidic (i.e., pH greater than or equal to 7),

    OR

    - Neutralize the acidic material contained in the applicable transfer facility (i.e., restore pH to greater than or equal to 7). An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization.

13. If laboratory analysis is utilized to determine pH for item 12, the sample results shall be independently reviewed, i.e., the laboratory sample analysis value shall be confirmed to be greater than or equal to pH 7 by a second person.

14. If litmus paper testing is utilized to verify pH for item 12, Independent Verification of the results is required, i.e., the litmus paper must be verified by a second person to be indicative of greater than or equal to pH 7.

15. If inhibitors must be added to the transfer facility for item 12 and the value determined by the engineering evaluation must be transposed into the governing procedure, Independent Verification of the transposed value shall be performed.

16. If inhibitors must be added to the transfer facility for item 12, the inhibitor volume actually added to the transfer facility shall be Independently Verified.

17. Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER from a waste tank in ACIDIC CHEMICAL CLEANING MODE, an engineering evaluation shall be performed to ensure the OA contents in the waste tank is less than or equal to 4 wt.%. This can be established by tracking the cumulative number of gallons of 8 wt.% OA added to the treatment tank and by adding at least that many gallons of WW or IW, adjusted for specific gravity, to the tank.

18. At least one mixing device in the CHEMICAL CLEANING TANK shall be operated a minimum of 1 hour prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER.

19. Prior to start of waste tank mixing device operation in waste tanks in ACIDIC CHEMICAL CLEANING MODE, verification shall be performed to ensure that sufficient water has been added to the waste tank to ensure the OA content in the waste tank (once mixed) will be less than or equal to 4 wt.%. that a volume of water equal to or greater than the volume of OA has been added to the waste tank to ensure the oxalic acid content in the waste tank (once mixed) will be less than or equal to 4 wt. %. This can be established by tracking the number of gallons of 8 wt.% OA added to the treatment tank and by adding at least that many gallons of WW or IW, adjusted for specific gravity, to the tank. IV is required for the following items:

    - Each OA tanker volume addition and the total (cumulative) amount of OA added for determining the amount of dilution water.
    - Volume of dilution water needed.
    - Volume of dilution water actually added.
    - Dilution water source valve line up, if a totalizer is used for volume determination.

20. Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), verification shall be performed to ensure that sufficient inhibitors are present in the applicable receipt waste tank to ensure neutralization of the acidic waste. An engineering evaluation shall determine the amount of inhibitors required to ensure neutralization in the receipt waste tank.

21. If inhibitors must be added to the receipt waste tank as described in item 20 and the value determined by the engineering evaluation must be transposed into the governing procedure, Independent Verification of the transposed value shall be performed.

22. If inhibitors must be added to the receipt waste tank as described in item 20, the volume actually added shall be Independently Verified.

23. During receipt of CHEMICAL CLEANING TRANSFERS (or related vent/drain operations), at least one mixing device shall be operating in the applicable receipt waste tank.

24. Prior to TRANSFER INITIATION of a CHEMICAL CLEANING TRANSFER (or related vent/drain operations), the transfer procedure shall Independently Verify that at least one mixing device is operating in the applicable receipt waste tank. Additionally, the transfer procedure shall require shut down of the transfer if it is found that at least one receipt waste tank mixing device is not operating during the transfer.

25. During receipt of CHEMICAL CLEANING TRANSFERS, acidic waste shall enter the receipt waste tank via a flow path below the waste tank liquid level. Prior to TRANSFER INITIATION, the transfer procedure shall perform Independent Verification of the waste transfer valve line-up to ensure that the acidic waste material will enter via a flow path below the receipt waste tank liquid level.

26. Post transfer vent and drain operations into Tank 51 for the transfer line low point located south of Tank 51 are permitted through the transfer line that traverses the annulus and the tank is permitted to receive acidic waste above the liquid level due to limited volume.

4.29 H-AREA TRANSFER FACILITY TRANSIENT FIRE LOADING (TSR 5.8.2.21) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.21.s

Prior to TRANSFER INITIATION of a HIGH-REM WASTE TRANSFER through an H-Area transfer facility, transient fire loading energy contribution in the affected transfer facility shall be less than or equal to 630,000 British Thermal Units (approximately 79 lb_{wood} equivalent). (SAC)

> DSA Section 3.4.2.5 "Transfer Facility Fire" assumed maximum amount of readily combustible material contributes no more than 2.5 million BTUs (approximately 313 lb_{wood} equivalent) of energy. The unmitigated consequences of the Transfer Facility Fire accident did not challenge the Offsite EGs (due to the initial conditions established by the Fire Protection Program), but exceeded the Onsite EGs. In the Transfer Facility Fire case, where the Transfer Facility Fire accident unmitigated consequences exceeded the Onsite EGs (i.e., HIGH-REM WASTE TRANSFER through HTF transfer facilities) the mitigated source term for HTF transfer facility fire is reduced by limiting the transient fire loading to approximately 630,000 BTUs (approximately 79 lb_{wood} equivalent). For HIGH-REM WASTE TRANSFERS through an H-Area transfer facility, the Transfer Control Program verifies combustible loading prior to initiating the transfer.

IMPLEMENTATION:

Transient fire loading energy contribution shall be documented in a calculation and may be performed by a visual inspection prior to close-out of the transfer facility or by an analysis of video/photograph(s) from a camera inspection. A Fire Protection Engineer shall provide concurrence of the transient fire loading energy contribution calculation. Verification that transient fire loading energy contribution is within limits prior to TRANSFER INITIATION of HIGH-REM WASTE TRANSFER is performed in accordance with established procedures or engineering evaluation.

Implementation Items:

1. HIGH-REM WASTE TRANSFER procedures shall include verification of transient fire loading energy contribution in the affected H-Area transfer facility is less than or equal to 79 lb_{wood} equivalent prior to initiation of the transfer.

4.30 EVAPORATOR FEED QUALIFICATION PROGRAM (TSR 5.8.2.25) (SAC)

ATTRIBUTE REQUIREMENT: 5.8.2.25.e

Prior to providing waste feed to the 242-25H evaporator, ensure that the supernate nitrite concentration in the feed tank is greater than or equal to 0.0275M.

The Evaporator Feed Qualification Program (CST DSA Section 5.5.4.2.25) also ensures the composition of waste in the 242-25H Evaporator tank complies with the hydrogen generation rate limits prior to transfer to the evaporator pot, and refers to CSTF DSA section 3.4.1.5.5.

IMPLEMENTATION:

See the Evaporator Feed Qualification Program Description Document for limits and implementation actions [Reference 10].

5.0 OTHER COMMITMENTS RELATED TO WASTE TRANSFERS

The following are other commitments related to waste transfers from various documents. These commitments shall be implemented.

5.1 FFA COMMITMENTS (REFERENCE 19)

1. Secondary Containment: Tank Systems will be operated with a leak detection system so that it shall detect the failure of either the primary or secondary containment structure of the presence of any leak of hazardous or radioactive constituents, hazardous substances, or accumulated liquid in the secondary containment system within 24 hours or the earliest practicable time, if DOE can demonstrate that the existing detection technology or site conditions would not allow detection of a leak within 24 hours. (FFA Section IX, Appendix B, C.1(c))

2. Waste tanks Leak Detection and Containment: If the leak was to the environment, within 24 hours after detection of the leak, or if it is demonstrated that it is not possible, at the earliest practicable time, remove as much of the hazardous/radioactive substance as is necessary to prevent further release of hazardous or radioactive substances to the environment and to allow inspection and repair of the tank system(s) to be performed. (FFA Section IX, Appendix B, D.1(b))

3. Waste tanks Leak Detection and Containment: If the leak was to a secondary containment systems, all accumulated materials shall be removed from the secondary containment systems within 24 hours or in as timely a manner as is possible to prevent harm to human health and the environment. (FFA Section IX, Appendix B, D.1(c))

5.2 WASTEWATER PERMIT COMMITMENTS

1. Once waste removal begins on a tank with a leak or crack and the waste is removed to a level below the lowest known leak or crack, that level shall become the maximum operating level of the tank and shall not be exceeded unless the exceedance is a temporary result of the waste removal process. (Reference 3, Special Condition # 6)

2. No tank that leaks or has leaked shall be used for waste receipt without prior approval from DHEC. This condition does not apply to the necessary addition of waste for waste removal purposes. (Reference 3, Special Condition # 7)

3. Based on a review of the Tank Assessment Report, submitted as a requirement of the Federal Facilities Agreement (FFA), Section IX, DHEC has determined that the Type I tanks identified as tanks 2-8 are approvable as equivalent devices for secondary containment. The Type I tanks, however, should only be used for waste receipt when there is no suitably available volume in an approved Type III tank. Furthermore, if any Type I tank develops a leak, which exceeds the capacity of the 5-foot deep secondary containment pan, this approval shall be rescinded and no additional waste shall be directed to these Type I tanks. (Reference 3, Special Condition # 11)

4. Type IV tanks do not meet secondary containment requirements. Tanks 21-24H are fit for use as low level waste receipt tanks until their scheduled waste removal date. (Reference 3)

5. The following five transfer lines are permitted to be used:

   - HDB-5 to Tank 21 (Line 102E)
   - HDB-5 to Tank 22 (Line 103E)
   - HDB-5 to Tank 23 (Line 101E)
   - HDB-5 to Tank 24 (Line 1825)
   - Tank 14 to Tank 13 (Line 21E)

   At the time of the Wastewater permit approval, the lines listed above did not meet the secondary containment (Reference 4). It was proposed that two lines (lines 1825 and 21E) would be decommissioned with the associated tank systems. The other three lines (101E, 102E, 103E) would be evaluated for need of repairing these lines for secondary containment requirements.

   Since the permit approval, HDB-5 to Tanks 21 and 22 transfer lines (102E, 103E) have been modified to meet the secondary containment requirements. Also, DHEC had been informed that HDB-5 to Tank 23 transfer line (101E) will not be modified and will be decommissioned with the associated tank systems. (Reference 4 and Electronic mail to DHEC from Chuck Hayes on 6/25/97)

6. The following two filtrate transfer lines do not meet secondary containment requirements:

   - Line FT-702A (M-M6-H-8213)
   - Line FT-1104A (M-M6-H-8214)

   These two transfer lines are required to be hydrostatic tested every two years to confirm no leakage exists. (Assessment Report Phase I for ITP Treatment Facility). These lines are not in service since the ITP Filtrate Building is not in service and hydrostatic testing is not required per Environmental Compliance Group.

5.3 AUTHORIZATION AGREEMENT COMMITMENTS (REFERENCE 9)

1. Waste transfers into Type I and II Tanks are prohibited unless the transfers are used to retrieve the waste contained in Type I, II or IV Tanks except as follows. Transfer of aluminum laden supernate, from sludge batch preparation, into Tank 241-908F and Tank 241-911H is allowed. Transfer of DWPF recycle into Tank 241-913H is allowed. Transfer of supernate from Tank 241-942H to Tank 241-913H is allowed.

2. Storage of In-Tank Precipitation process precipitate and supernate in Tank 241-949H is only permitted in the event of a leak in the primary containment of Tank 241-948H and following DOE approval of a RESPONSE PLAN.

3. Tank Closure activities may be performed in accordance with the CSTF Safety Basis Documents listed in Manual WSRC-IM-94-10, and applicable Industrial Wastewater Closure Plans, and Tank Specific Closure Modules.

5.4 BEST MANAGEMENT PRACTICES

1. Area radiation monitoring with a local alarm shall be provided at the gang valve house during a jet waste transfer. This includes lift and lance gang valve operations for evaporator operations. Above-ground gang valves are used to route steam to transfer jets. Under normal conditions, the gang valve assembly does not contain waste. However, if steam flow through the gang valve is interrupted during a transfer, and the automatic air blow feature fails and the gang valve does not go to the maintenance position, waste can be sucked back into the gang valve assembly due to trapped collapsing steam. If this occurs, high radiation rates at the gang valve piping could result. The purpose of this monitoring is to provide personnel protection at locations where potentially high radiation rates can exist as a result of a waste transfer.

2. DWPF Qualified Sludge Feed Tank shall be isolated from the TRANSFER PATH by sound double valve isolation, a single leak-tested valve or a blank to prevent contamination of the qualified DWPF feed. Tank 40 Drain Valve Box Valve WTS-V-20 cannot be leak checked. However, this valve is seldom opened and several transfers were performed previously, which placed this valve in the TRANSFER PATH without any indication of leak by. Therefore, valve WTS-V-20 in Tank 40 Drain Valve Box need not be leak checked.

3. If the receiving or transfer tank, excluding evaporator recycle transfers, is a salt tank, identify in the transfer evaluation and approval procedure a requirement to initiate radiation surveys on purge HEPA housing of the transfer/receipt salt tank shiftly for the duration of the transfer. This BMP requirement is based on past experience with purge HEPA filters build-up during the salt tank transfers.

4. To prevent the HPFP from being a LEAK DETECTION LOCATION during a HIGH-REM WASTE TRANSFER using HPT-7 Pump 2, pneumatic valve WTS-FV-6953 (if seismically qualified for operability) shall be leak-tested or have a blank installed. This will preclude HIGH-REM material leakage into the HPFP sump, which would be transferred into FPT-1. Transferring HIGH-REM material into F-Tank Farm is prohibited.

5. Material balances shall be performed for pump tank transfers. For transfers like Canyon to pump tank (Continuous or batch), a single material balance at the end of the transfer is appropriate.

5.5 DOE MANUAL 435.1-1 COMMITMENTS (REFERENCE 24)

1. "Contingency Actions. The following requirements are in addition to those in Chapter I of this Manual.

   (1) Contingency Storage. For off-normal or emergency situations involving high-level waste storage or treatment, spare capacity with adequate capabilities shall be maintained to receive the largest volume of waste contained in any one storage vessel, pretreatment facility, or treatment facility. Tanks or other facilities that are designated for high-level waste contingency storage shall be maintained in an operational condition when waste is present and shall meet all the requirements of DOE O 435.1, Radioactive Waste Management, and this Manual." (DOEM435.1-1 Ch. 2-h.(1))

   This commitment is implemented by the waste transfer approval process via the "Electronic Transfer Approval Form", (ETAF).

6.0 REFERENCES

1. WSRC-SA-2002-00007, "Concentration, Storage, and Transfer Facilities Documented Safety Analysis".

2. S-TSR-G-00001, "Technical Safety Requirements, Concentration, Storage, and Transfer Facilities".

3. SCDHEC Permit to Operate #17,424-IW, "F and H-Area High-Level Radioactive Waste Tank Farms", March 3, 1993.

4. ESH-FSS-92-0811, "Phase II Tank Assessment report for the F and H-Area High Level Radioactive Waste Tank Farms", November 30, 1992.

5. X-CLC-H-00305, "Requirements to Prevent Exceeding the CST 830 DSA Bounding Sludge Slurry Source Term in H-Area Waste Tanks".

6. X-CLC-G-00025, "Requirements to Prevent Exceeding the CST 830 DSA Bounding Slurried Type IV Tank Source Term in H-Area Waste Tanks".

7. WSRC-TR-2002-00260, "Lower Source Terms for F-Area Tanks", by P. D. d'Entremont, J. K. Jeffrey, J. R. Hester, P. J. Hill.

8. Marks' Standard Handbook for Mechanical Engineers, 10th Edition.

9. N-AA-G-00001, "U.S. Department of Energy Savannah River Operations Office and Savannah River Remediation, LLC Authorization Agreement (AA) for the Concentration, Storage, and Transfer Facilities (CSTF)".

10. WSRC-TR-2003-00055, "Evaporator Feed Qualification Program Description Document".

11. X-ESR-H-00052, "Sampling Methodology for DSA Administrative Programs".

12. WSRC-TR-2002-00327, "Tank Farm Corrosion Control Program Description Document".

13. S4-OPS.20, "Crane Operations and Critical Lifts in LW Facilities".

14. U-ESR-G-00032. "Area Radiation Monitor (ARM) Location Program for the EMD Submersible Transfer Pump (STP) Operations".

15. Procedure S4-ENG.8, "Waste Acceptance Criteria, Waste Compliance Plan, and Special Waste Compliance Plan".

16. WSMS-LIC-03-00156, "Inhalation Dose Potential of Pump Pit Sump Contents".

17. WSRC-TR-2003-00157, "A Graded Approach to Salt-Out Evaluations for Waste Transfers in the Tank Farm", J. K. Jeffrey.

18. Deleted.

19. WSRC-OS-94-42 (Administrative Document Number 89-05-FF), "Federal Facility Agreement for the Savannah River Site".

20. N-ESR-G-00001, "High Level Waste Emergency Response Data and Waste Tank Data".

21. M-ESR-S-00015, "An Evaluation of Water Hammer Occurrence in the Tank Farm Waste Transfer System".

22. WSRC-RP-93-900-TL, "Recommended Flow Rates for Flushing the Hydrogard Sampler".

23. WSRC-RP-93-800, "Flushing the H-S Inter-area Transfer Lines".

24. DOE Manual 435.1-1, "Radioactive Waste Management Manual, Chg. 1".

25. X-CLC-G-00062, "LOWREM Transfer Table".

26. X-ESR-F-00056, "Area Radiation Monitor (ARM) Location Program For Above-Ground HIGH-REM Transfers and SMP Operations"

27. Deleted.

28. M-CLC-G-00263, "Over pressurization - F & H Area Waste Transfer System".

29. M-CLC-G-00283, "Volume calculations for FTF/HTF Diversion Boxes, valve Boxes and their Sumps".

30. D. T. Herman, et. al., "Investigating Hydrogen Generation and Corrosion in the Treatment Tank and the Potential Formation of a Floating Layer in the Neutralization Tank During Waste Heel Chemical Cleaning," WSRC-STI-2007-00209, April 30, 2007.

31. U-ESR-G-00015, "Comparison of Operation of Standard Slurry Pumps versus Quad Volute Pumps".

32. Faugl, T., "Determination of Generic Inhalation Dose Potential Uncertainty (2-Sigma)", U-CLC-G-00035

33. East, J.M. and Lewis, M.C., "SRS High Level Waste Chemical and Radiological Consequence Analysis (U)", S-CLC-G-00280, Rev. 0, May 2002.

34. Speight, B.A., "Evaluation of the CSTF Radiological and Chemical Consequence Comparison Basis", G-ESR-H-00232, Rev. 0, June 2017.

35. U-DSA-H-00003, "Concentration, Storage, and Transfer Facilities Documented Safety Analysis Addendum: Operation of 242-25H Evaporator with Leak Sites", April 2018.

36. WSRC-TR-2003-00089, "CSTF Sludge Carryover Minimization Program Description Document".

37. M-ESR-F-00272 Rev. 1, "Engineering Evaluation of Potential Over-pressurization of F-Tank Farm Waste Transfer Lines during Inter-Area Transfers", S. Wallace, July 2018.

38. U-TRT-G-00012, CSTF Tank Closure Cesium Removal Operations Program, D. Martin, October 2018.

ATTACHMENT-1, LEAK DETECTION LOCATIONS

The definition of LEAK DETECTION LOCATION in the TSRs ended up being fairly simple. LEAK DETECTION LOCATIONS support waste primary containment SSCs (e.g., waste tanks, pump tanks, transfer lines). A LEAK DETECTION LOCATION is any structure or component (e.g., sump, leak detection box) credited with accumulating sufficient liquid waste that escapes primary containment to allow observation (e.g., by leak detection instruments or other methods). So, any single waste primary containment may have one or more LEAK DETECTION LOCATIONS associated with it. These will be the LEAK DETECTION LOCATIONS for that primary waste containment regardless of the status of the contents of the primary waste containment (e.g., pump tank empty or full, transfer line actively transferring or drained).

LEAK DETECTION LOCATIONS have Safety Basis requirements placed on them from several drivers. These drivers include LCOs and Administrative Controls. The applicability of several LCOs is dependent on the MODE of Transfer Lines for which certain LEAK DETECTION LOCATIONS are credited. Some of these LCOs are applicable in All MODES and others are applicable only in HIGH-REM TRANSFER MODE. The most straight-forward way to think of how these LCOs will become involved with the conduct of actual WASTE TRANSFERS in the facility is to first consider which transfer line segments (including jumpers) are associated with a given LEAK DETECTION LOCATION. After the correlation of line segments with LEAK DETECTION LOCATIONS is known, determining which LEAK DETECTION LOCATIONS are associated with a given transfer through the LCOs is simply a matter of determining all the line segments along the TRANSFER PATH (up to the first sound isolation point) and listing the LEAK DETECTION LOCATIONS for all those line segments.

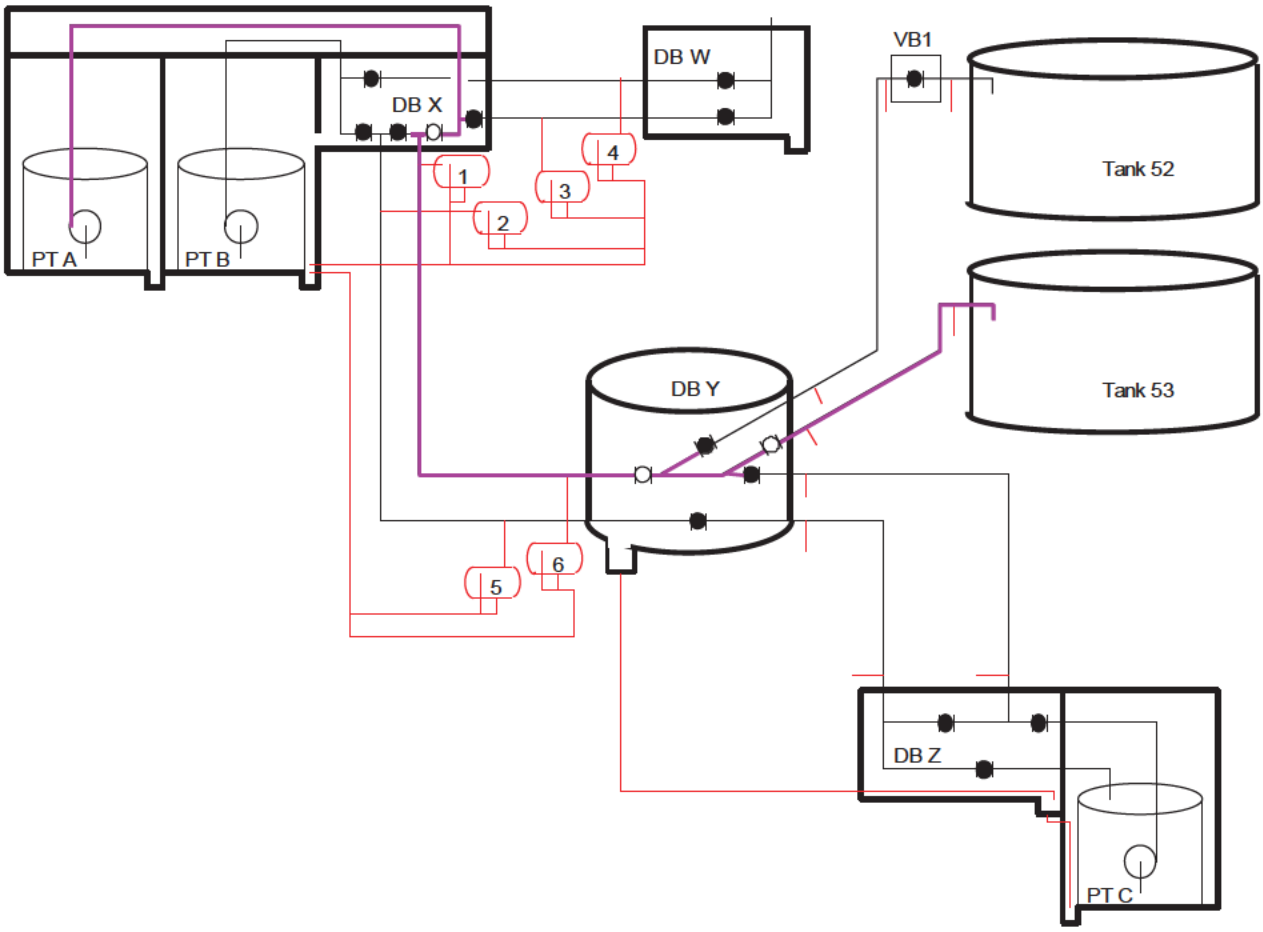
In addition to the requirements of the LCOs, the Transfer Control Program places requirements on LEAK DETECTION LOCATIONS. TSR AC 5.8.2.21.c requires monitoring of WASTE TRANSFERS to detect transfer events. The frequency and method (e.g., material balances, level/leak monitoring) of monitoring for a transfer and the required monitoring locations (including consideration of those past the first sound isolation point) shall be determined on an individual basis. So, although the LCOs only place requirements on LEAK DETECTION LOCATIONS along the TRANSFER PATH, some level monitoring of certain LEAK DETECTION LOCATIONS associated with line segments off the TRANSFER PATH may be needed to properly implement the Administrative Control (e.g., sumps that are LEAK DETECTION LOCATIONS for transfer lines / jumpers that are between the first sound isolation point and the second sound isolation point).

LDBs/MLDBs/LPSs that are LEAK DETECTION LOCATIONS for line segments between the first and second sound isolation points are typically excluded from the monitoring requirements of TSR AC 5.8.2.21.c. The exclusion of these LBDs/MLDBs/LPSs is in part based on the high reliability of the welded core pipe that these LEAK DETECTION LOCATIONS support combined with the fact that the transfer is not expected to pressurize the line segments downstream the first sound isolation point.

The annulus for a waste tank is a LEAK DETECTION LOCATION for the transfer lines that pass through the annulus. This is because the portions of the transfer line jacket that pass through the annulus are not credited with being leak-tight. Waste tank annuli that are LEAK DETECTION LOCATIONS for transfer lines on a TRANSFER PATH are typically monitored as part of TSR AC 5.8.2.21.c. Waste tank annuli that are LEAK DETECTION LOCATIONS for line segments beyond the first sound isolation point of a TRANSFER PATH are typically excluded from the monitoring requirements of TSR AC 5.8.2.21.c. The exclusion of these annuli is based in part on the high reliability of the welded core pipe that these LEAK DETECTION LOCATIONS support combined with the fact that the transfer is not expected to pressurize the line segments downstream of the first sound isolation point.

Examples:

Consider the TRANSFER PATH from Pump Tank A to Tank 53 shown in the simplified diagram below.



In this diagram, Diversion Box X has a large credited drain from the box into Pump Pit B. Therefore, Diversion Box X is not a credited LEAK DETECTION LOCATION (waste cannot accumulate there). Diversion Boxes Y and Z also have drains, but these drains are too small to ensure that waste will not accumulate. Diversion Boxes Y and Z also have no weirs or similar devices to ensure that leakage into these boxes will be detected before the liquid exits the box.

The TRANSFER PATH is shown in dark solid line in the above diagram. The LEAK DETECTION LOCATIONS for all the line segments/jumpers along the TRANSFER PATH are: Pump Pits A, B, and C, Diversion Boxes Y and Z, LDBs 1 and 6 (and two more LDBs between DB Y and Tank 53 that are not fully shown or identified). Note that the only reason Diversion Box Z and Pump Pit C are LEAK DETECTION LOCATIONS for line segments/jumpers on the TRANSFER PATH is because of the "cascading sump" issue from Diversion Box Y.

LCO requirements (e.g., sump level, conductivity probe operability, or ventilation) typically do not vary based on whether or not a transfer is in progress. LCO requirements are applied based on the MODE the associated PROCESS AREAS are in. Transfer Lines only have two MODES – OPERATION, and HIGH-REM TRANSFER. LCOs of concern typically are applicable to Transfer Lines in either All MODES or only during HIGH-REM TRANSFER MODE. Some of these LCOs also apply to Pump Tanks, which have different MODES from Transfer Lines.

Therefore, even if the transfer from Pump Tank A to Tank 53 was a HIGH-REM WASTE TRANSFER, the conductivity probe in Diversion Box W would not be required to be operable by LCO 3.7.3 as long as all the Transfer Lines for which Diversion Box W was a LEAK DETECTION LOCATION remained in OPERATION MODE. The conductivity probe in Diversion Box Y would be required to be operable because the Transfer Lines and jumpers in DB-Y that are on the TRANSFER PATH would have to be in HIGH-REM TRANSFER MODE to support the transfer. The conductivity probe in Diversion Box Z would also be required to be operable not because any Transfer Lines within the diversion box were in HIGH-REM WASTE TRANSFER MODE, but because of the cascading sump issue from DB-Y.

LCO 3.7.4 for Valve Boxes, Drain Valve Boxes, and the HPFP ends up applying differently to this scenario than the Diversion Box LCOs. Even though the TRANSFER PATH from Pump Tank A to Tank 53 does not include the Transfer Line through Valve Box 1 (TRANSFER PATH stops at first closed valve in Diversion Box Y), if the closed valve in Diversion Box Y is not leak checked the Transfer Line into Valve Box 1 is required to be in HIGH-REM TRANSFER MODE (even though the line segment is not on the TRANSFER PATH of the HIGH-REM WASTE TRANSFER). Thus, if this were the case, the conductivity probes in the LDBs between DBY and VB1 would be required to be operable per LCO 3.7.4. Refer to TSR Section 1.6.4 Item 3 for Transfer Lines in OPERATION MODE.

Administrative Controls are applicable to Waste Transfers separately from LCO requirements. TSR AC 5.8.2.21.c requires monitoring of WASTE TRANSFERS to detect transfer events. This typically requires monitoring not only the sending and receiving tank levels, but also appropriate monitoring of tanks that could potentially receive flow from transfer events. It also requires appropriate monitoring of LEAK DETECTION LOCATIONS – both those along the TRANSFER PATH and the ones associated with Transfer Line segments outside the TRANSFER PATH where transfer events could occur.

Implementing TSR AC 5.8.2.21.c requires monitoring waste tanks, pump tanks, and LEAK DETECTION LOCATIONS for all transfer line segments along the TRANSFER PATH. Additionally, monitoring waste tanks and pump tanks isolated from the TRANSFER PATH by a single non-leak checked valve and LEAK DETECTION LOCATIONS (excluding LDBs/MLDBs/LPSs and waste tank annuli) for transfer line segments isolated from the TRANSFER PATH by a single non-leak checked valve is typically required. Exceptions may be taken to this standard approach of implementing TSR AC 5.8.2.21.c, but they must be justified on a case-by-case basis.

So even though a LEAK DETECTION LOCATION may not have LCO-driven leak detection instrument requirements or level requirements for a transfer, the TSR Administrative Control

Program may determine that certain monitoring requirements are needed in those LEAK DETECTION LOCATIONS during the transfer.

Waste Characterization System Program Description Document

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SUMMARY OF REVISIONS:

Date	Revision	Description of Changes
2/14/2003	0	Initial Issue
3/11/2003	1	Addition of backup/recovery discussion, addition of Reference 7, clarification of data entry for pre-transfer projections, and editorial changes
6/04/2004	2	Preparation for implementation of a new WCS platform (a web based program) to include clarification for the required changes associated with re-establishing WCS 1.5, deleted reference to the Sample Management Plan, added discussion of salt/sludge volume information sources to include engineering calculations and technical reports, modified PDD format, incorporated the role and responsibility of the DIRT committee for coordination and execution of the PDD implementation items
7/2014	3	Added reference to DIRT Charter, reformatted PDD and added appropriate content to conform to latest S4-Eng. 36 procedure
12/2015	4	Removed some information that can be found more appropriately in the DIRT Charter. Updated implementation actions and included additional information regarding Canyon transfers and Tank 50 Material Balance updates.
6/2017	5	Revised PDD to address implementation of WCS Online web based application that replaced WCS 1.5. Added 4.3 to specify WCS sample results are only updated for corrosion and flammability purposes. Updated Reference Section to update current documents and add new WCS Online implementing and software lifecycle documents Revised Section 4.1.2 to reflect requirements of B-DMP-H-00006 for Data Entry Controls. Updated PDD to align with the requirements of S4-ENG.36.

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1.0 PURPOSE

The purpose of this Program Description Document (PDD) is to provide guidance to Engineering personnel for implementing the associated requirements contained in the Documented Safety Analysis (DSA 5.5.4.2.32) [Ref. 1] and Technical Safety Requirements (TSR 5.8.2.32) [Ref. 2], pertaining to the Liquid Waste (LW), Waste Characterization System (WCS) Administrative Control Program. The WCS Program shall address data acquisition, data entry, and quality assurance.

The WCS was developed for the purpose of establishing and maintaining a data source for waste composition in all high level waste tanks in the Concentration, Storage and Transfer Facilities (CSTF). WCS is a web-based application (WCS Online) which primarily stores supernate, salt, and sludge data. This application accommodates data input (e.g., waste characterization, tank levels, and chemistry) for supernate, sludge and salt.

Additionally, WCS implements requirements of other PDDs, the Waste Acceptance Criteria (WAC) Program, and other programs supporting LW operations. Certain calculations are performed within the database, using the input data, to determine conditions and other parameters associated with various administrative control programs (i.e.., Flammability Control Program, Corrosion Control Program, Transfer Control Program, Sludge Carryover Minimization Program, Evaporator Feed Qualification Program, Hydrogen Generation Rate Control Program, Prohibited Operations Program, Gas Release Program, Tank Fill Limits Program, Waste Tank Quiescent Time Program, Inhalation Dose Potential Control Program, Waste Tank Chemical Cleaning Program, ARM Location Program, Waste Acceptance Criteria Program, Tank 48 Unauthorized Operations Program, and Flammable Vapor Sampling Program). Calculations are addressed by WCS Technical Baseline documents and not this PDD, however a description of the process is provided in the PDD to provide an overview of the entire system.

2.0 SCOPE

The scope of this PDD is the WCS database and the guidance for implementing the requirements of TSR 5.8.2.32) [Ref. 2]. Additional WCS information is provided to present the process in total, but the intent of the PDD is to ensure the program meets the TSR requirements for data.

This document is not a Safety Basis Document or a safety basis implementing document.

PDD Owner Qualifications and Responsibilities are established in S-4 Manual, Procedure ENG.36 [Ref. 3] and are not addressed by this document.

3.0 BACKGROUND

3.1 Safety Function

The safety function of this PDD is to ensure that programmatic controls are established to address data acquisition, data entry, and quality assurance as required by the TSR.

3.2 Other Drivers

N/A

4.0 PROGRAM DESCRIPTION

4.1 Inputs

4.1.1 Data Acquisition

There are several sources of information and data utilized by WCS. The following requirements are designed to establish a connection between various information sources and the WCS owner.

All reports or approved documents that contain results from waste tank samples shall be forwarded to the organization that owns the WCS. Sample results required by administrative programs shall be incorporated into WCS in accordance with the specific requirements identified within the affected administrative programs.

The results of sludge and salt soundings are to be reported to the organization that owns the WCS. This information is key to performing the providing the data required to support the various program calculations implemented in the WCS. This communication shall be accomplished by the reporting requirements in the procedure for performing a salt or sludge sounding (i.e. SW11.1-WTE-7.2). Typically, the sample coordinator works closely with the facility to coordinate soundings measurements and to collect the results of the soundings.

Sludge and salt soundings may not be the most effective method for determining the amount of salt and sludge in a tank, especially after bulk waste removal has been initiated by the Waste Removal or Salt Removal Programs. These programs typically utilize video inspections and sampling as additional means to establish the tank heel. These results are documented in a Technical Report or Engineering Calculation. Similar evaluations are often performed during intermediate bulk waste removal processing and after salt dissolution and mining activities. These evaluations shall be forwarded to the organization that owns WCS.

The WCS must be updated with sludge canyon receipts (e.g., H-Canyon). The receipts of waste into the Tank Farm are reported on Workgroup 8 (\\WG08) shortly after the transfers are completed. An evaluation is performed at least semi-annually to determine the heat loads associated with these transfers for incorporation into the WCS Online database. By updating the canyon receipts in a timely manner, WCS will reflect a close approximation of what is in each tank at any given time. The typical canyon transfer is less than 2,000 gallons. Assuming there are 10 canyon transfers in a month, the addition to a tank is less than 20,000 gallons. The heat contribution corresponding to 20,000 gallons is inconsequential compared to the heat inventory represented within a typical sludge tank. Several months of typical canyon transfers are required to significantly impact the characterization of a receipt tank.

Additionally, impact reviews are performed prior to special canyon transfers, approved through a special Waste Compliance Plan, into Tank Farm waste tanks; therefore, significant impacts are evaluated and accounted for in advance. Currently, the major repository for Canyon waste is Tank 39. Tank 39 is re-baselined at least semi-annually to verify its separation distance requirements and update heat loads. Re-baseline frequency will be re-evaluated commensurate with changes to the system plan or, at a minimum, during the bi-annual self-assessment. The changes in supernate chemistry resulting from the H-Canyon receipts are captured by periodic samples per the Corrosion Control Program [Ref. 4].

The WCS must be updated with sludge receipts from DWPF into CSTF. These receipts of waste into the Tank Farm are reported on Workgroup 8 (\\WG08) shortly after the transfers are completed. An evaluation is performed to determine the heat loads associated with these transfers. The results are then utilized to determine the quantity of sludge solids that can be accepted into the designated waste tank. The number of allowable transfers is calculated using a conservative estimate of the quantity of sludge solids per transfer. The number of allowable transfers is reflected in the Emergency Response Data (ERD) such that the maximum quantity of sludge solids is not exceeded. Periodically (when transfers reach approximately 75% of allowable transfers) DWPF will provide an evaluation detailing actual transfer sludge solids data as determined by sample results for incorporation into WCS Online.

Tank 50 receives transfers (non-waste) from ETP, H-Canyon, 512-S, and MCU. As required by the Saltstone WAC [Ref. 5], a material balance of Tank 50 is performed routinely. The Tank 50 Material Balance data in WCS Online has to be updated accordingly. SRNL issues WAC sample data tables. WAC sample data is used to update the Latest Baseline Sample section. Operations input all transfers into and out of Tank 50 into the Isopar Concentration Calculator (ICC). A WCS Online request is generated so that the Tank 50 Material Balance data in WCS Online can be updated with the sample and transfer data. The WAC sample data is input as a Re-baseline periodically. Total transfer volumes are entered, according to transfer waste stream (e.g. ETP, Salt Batch), into the Tank 50 Material Balance worksheet periodically.

All other waste streams coming into the CSTF from outside facilities are similarly required to comply with the CSTF WAC [Ref. 6]. Characterization data from these streams are presented to Data Integrity Review Team (DIRT) where it is determined whether or not WCS needs to be updated or not [Ref. 23].

Prior to entry into WCS, sample data, solids measurements, Tank 50 Material Balance updates, and applicable engineering reports are reviewed by DIRT. As described in the DIRT Charter [Ref. 23], DIRT is a body of personnel, selected by specific technical expertise, designed to represent a quorum of sufficient engineering breadth to provide a holistic perspective to data review. The mission of the DIRT is to review CSTF waste tank characterization data (e.g., chemistry and sounding measurements) to verify its technical validity prior to the incorporation of the data into WCS. Additionally, the DIRT coordinates the execution of the implementation items identified in this WCS

PDD. The major repository for DIRT evaluated data is WCS Online. DIRT meetings are conducted at least monthly (typically weekly) to ensure WCS is updated appropriately.

4.1.2 Data Entry and Quality Assurance

The following guidelines are given to ensure that the data entered into the WCS retains the pedigree commensurate with Level B software. All data entry shall be in compliance with Waste Characterization System Online Data Management Plan (DMP) [Ref. 8] and consistent with the requirements outlined in Manual E7, Procedure 5.80A [Ref. 13]. This DMP outlines the steps necessary to properly document and verify data entered into the WCS Online database.

A Request Form is required for all data entry into WCS Online. Request form process and requirements are found in B-RS-H-00272, *Waste Characterization System Online Software Requirements Specification* (RSS) [Ref. 18]. WCS Online also requires an independent review for all data entry. This process and requirements can also be found within the RSS. The Request Form process within WCS Online is the primary error reporting mechanism for data problems that can be addressed via the application. If data errors, other corrections or additions to WCS Online data are required and cannot be performed through the standard data entry process, a request to the Design Agency to perform necessary changes should be submitted via Data Modification Tracker (DMT).

WCS Online Data Error Reporting and Corrective Action is addressed by the WCS Online DMP [Ref.8]. Per the E7 Conduct of Engineering Manual, Procedure 5.80A, *LW Data Management* [Ref. 13], changes to data or the structure of a database, resulting from errors, quality issues, or new requirements, are reported and controlled by a DMT (OSR 46-523) or other appropriate and approved change control methodology that contains the same essential elements. DMTs will be reviewed and approved in accordance with the E7 Conduct of Engineering Manual for LW Data Management [Ref.13]. Independent reviews are performed for both Request and DMTs associated with WCS Online per E7 Manual requirements.

To address backup and recovery, including disaster recovery, the production version of WCS shall be hosted on a server that provides daily back-up of all files. Back-ups shall be maintained to be available to recover from a failure of the production server. The documents managed as baseline documents include the technical baseline documents (5 modules), RSS) [Ref. 18] and the DDS [Ref. 10], RTM [Ref. 19]. For all other concerns regarding the quality assurance of this WCS, refer to the SQAP [Ref. 17].

4.2 Key Attributes

The key attribute of the WCS Program, addressed by this PDD, is the data entry into the WCS Online application, data integrity, and quality assurance. The integrity of the WCS Program is reliant on the respective pedigrees of the data entered. It is essential that controls are in place to protect the validity of each. This PDD is designed to outline how these controls are implemented.

4.3 Programmatic Assumptions

Samples that are "accepted" by DIRT are entered into WCS within two weeks of acceptance (for those results that are required to be entered into WCS). Not all accepted sample data are utilized in WCS. For example, variable depth sample results are often utilized in engineering evaluations/calculations; however, typically only Corrosion Control (CC) surface samples are entered into WCS as the representative supernate chemistry. Unless otherwise indicated in WCS, sample results are entered "as reported", without any adjustment for uncertainty.

4.4 Evaluation, Criteria for Evaluation, Bases for Criteria, Inputs and Outputs

4.4.1 WCS Online Baseline

The calculations used to establish a basis for operation, set action limits, and determine operational status (e.g. flammability status of RAPID) or provide any other key safety related parameters are not addressed specifically as part of this PDD. The WCS formulas, evaluations, criteria for evaluations, bases for the criteria and outputs are established as a Level B software program as delineated in Manual E7, 5.01 [Ref. 12], Manual 1Q QAP 20-1 [Ref. 16], and the applicable Software Quality Assurance Plan (SQAP), [Ref. 17].

WCS Online Technical Baseline documents (modules) provide the formulas for the WCS Program to include inputs and outputs for the calculations. The Requirements Software Specification (RSS) establishes the requirements for the application [Ref. 18]. The Design Document for Software (DDS) [Ref. 10] incorporates this baseline into the WCS Online design. A Requirements Traceability Matrix (RTM) [Ref. 19] is maintained to link requirements, design elements, and test cases for the application version in production. The WCS Online Technical Baseline documents (modules) were reviewed and approved in accordance with Manual E7, Procedure 2.31A [Ref. 11]. The WCS Online design was tested and accepted per Manual E7, Procedure 5.01, Manual 1Q, QAP 20-1, and the associated SQAP.

All WCS calculations are clearly presented in the WCS Technical Baseline (5 modules) to include inputs, assumptions and uncertainty considerations appropriately referenced and justified as listed below:

- X-ESR-H-00718, WCS Online Chemical and Radiological Characterization Module (Module 1) Calculations Methodology [Ref. 24]

- X-ESR-H-00723, WCS Online Generic Equations and Conversions Module (Module 2) Calculations Methodology [Ref. 25]

- X-ESR-H-00729, WCS Online Corrosion Module (Module 3) Calculations Methodology [Ref. 26]

- X-ESR-H-00736, WCS Online Flammability (Module 4) Calculations Methodology [Ref. 27]

- X-WSR-H-00740, WCS Online Material Balances and Reports (Module 5) Calculations Methodology [Ref. 28]

4.5 WCS Online Implementation / Modification

Additionally, a Software Quality Assurance Plan (SQAP) [Ref. 17], was revised to provide software lifecycle requirements for the WCS Online application. The SQAP governs the methods that must be used to maintain the WCS Online software as Level B software in accordance with Manual 1Q, QAP 20-1 [Ref. 16]. The SQAP requires that the Computer Program Modification Tracker (CMT), as a minimum, document modifications to baseline computer program files. These modifications shall be identified as Configuration Items (CIs). This includes software changes such as configuration, Operating System (OS) System Settings, Application System Settings, and Database Settings made in accordance with Manual E7, Procedure 5.62A [Ref. 14]. The required design documents, to include technical baseline documents (modules) [Ref. 24-28], Requirements Specification for Software (RSS) [Ref. 18], Design Document for Software (DDS) [Ref. 10], and Requirements Traceability Matrix (RTM) [Ref. 19], will be revised as necessary to implement the changes to WCS Online.

4.6 Implementation Actions

1. Reports or approved documents that contain results from waste tank samples (as described in section 4.3) shall be forwarded to the organization that owns the WCS. After sample results are received, they shall be evaluated through DIRT for inclusion into WCS.

2. Waste Removal or Salt Removal Program tank heel evaluations (e.g., technical report or engineering calculations) shall be forwarded to the organization that owns the WCS. After tank heel evaluation information is received, they shall be evaluated through DIRT for inclusion into WCS.

3. Reports or approved documents that contain results from waste tank sounding measurements shall be forwarded to the organization that owns the WCS. After sludge and/or salt sounding results are received, they shall be evaluated through DIRT for inclusion into WCS.

4. Reports or approved documents (e.g. work packages, procedures) that contain results from waste tank mixing device or transfer device location change or installation shall be forwarded to the organization that owns the WCS.

5. An evaluation shall be performed at least semi-annually to determine the heat loads associated with the Canyon receipt transfers.

6. DWPF receipts including sludge shall be evaluated through DIRT for inclusion into WCS.

7. Tank 50 Sample updates shall be evaluated through DIRT for inclusion into WCS. The Tank 50 Material Balance worksheet will be updated in WCS periodically with transfer volumes (into or out of Tank 50) from the Isopar Concentration Calculator (ICC).

8. The WCS software shall be maintained consistent with requirements for Level B software in accordance with Manual E7, Procedure 5.01 [Ref. 12] and Manual 1Q, QAP 20-1 [Ref. 16].

9. Sending Facilities (i.e. H-Canyon) that update Workgroup 8 folder (\\WG08) must communicate with WCS owner/DIRT Chairman.

10. Characterization data from other WAC controlled streams shall be evaluated through DIRT for inclusion into WCS Online.

5.0 OTHER COMMITMENTS

N/A

6.0 DEVIATION

Proposed Deviations from the Implementation Actions as contained in this PDD shall be evaluated for acceptance by the Program Review Committee per S4-ENG.36 [Ref. 3].

7.0 REFERENCES

1. WSRC-SA-2002-00007, Rev. 19, June 2016, *Concentration, Storage, and Transfer Facilities Documented Safety Analysis* [DSA]

2. S-TSR-G-00001, Rev.54, April 2017, *Concentration, Storage, and Transfer Facilities Technical Safety Requirements* [TSR]

3. S4, ENG-36, *Tank Farms Engineering Program Description Documents*

4. WSRC-TR-2002-00327, *CSTF Corrosion Control Program*

5. X-SD-Z-00001, *Waste Acceptance Criteria For Aqueous Waste Sent To The Z-Area Saltstone Production Facility*

6. X-SD-G-00001, *Waste Acceptance Criteria for Liquid Waste Transfers to the Tank Farms*

7. G-TRT-H-00033, *Data Integrity Review Team Charter*

8. B-DMP-H-00006, *Waste Characterization System Online Data Management Plan*

9. Manual E7, Procedure 5.80A, *LW Data Management*

10. B-DD-H-00076, *Waste Characterization System (WCS) Online Software Design Description*

11. Manual E7, Procedure 2.31A, *LW Engineering Calculations*

12. Manual E7, Procedure 5.01, *Software Engineering and Control*

13. Manual E7, Procedure 5.80A*, LW Data Management*

14. Manual E7, Procedure 5.62A*, LW Computer Program Modification Tracker*

15. Manual E7, Procedure 2.31A, *LW Engineering Calculations*

16. Manual 1Q, QAP 20-1, *Software Quality Assurance*

17. B-SQP-G-00053, *Software Quality Assurance Plan for LWO Engineering – Process Applications Organization* [SQAP]

18. B-RS-H-00272, *Waste Characterization System Online Software Requirements Specification*

19. B-RTM-H-00056, *Waste Characterization System Online Requirements Traceability Matrix* [RTM]

20. WSRC-TR-2003-00087, *CSTF Flammability Control Program*

21. WSRC-TR-2003-00089, *CSTF Sludge Carryover Minimization Program, Program Description Document*

22. SW11.1-WTE-7.2, *Transfer Jet/Pump/Waste Downcomer Levels and Adjustments Data Sheet*

23. G-TRT-H-00033, *Data Integrity Review Team (DIRT) Charter*

24. X-ESR-H-00718, WCS Online Chemical and Radiological Characterization Module (Module 1) Calculations Methodology

25. X-ESR-H-00723, WCS Online Generic Equations and Conversions Module (Module 2) Calculations Methodology

26. X-ESR-H-00729, WCS Online Corrosion Module (Module 3) Calculations Methodology

27. X-ESR-H-00736, WCS Online Flammability (Module 4) Calculations Methodology

28. X-WSR-H-00740, WCS Online Material Balances and Reports (Module 5) Calculations Methodology

CSTF Tank Closure Cesium Removal Operations Program

Program Description Document

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02/04/2019

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Summary of Revisions

Revision	Date	Description
0	October, 2018	Initial Issue
1	February 2019	Incorporation of Program Description Document Deviation U-PDDEV-G-00001 Rev. 0, distinguished a pre-filter "backflush" from an IX Column "flush", description and implementation actions to permit Tank 10 Transfer Pump elevation changes during the QUALIFIED phase, clarified flushing requirements for more than two IX columns in series operation, updated References and reference numbering, other miscellaneous clarifications and edits.

Acronyms

^{o}C	Degrees Centigrade
Ci	Curie
CST	Crystalline silicotitanate
DIRT	Data Integrity Review Team
DMT	Data Management Tracker
DSA	Documented Safety Analysis
ERD	High Level Waste Emergency Response Data and Waste Tank Data
ETAF	Electronic Transfer Approval Form
g	gram
gal(s).	gallon(s)
ISS	Interim Safe Storage
IV	Independent Verification
IX	Ion Exchange
kg	kilogram
L	liter
m	milli
M	Molarity
mg	milligram
mL	milliliter
mol	mole
NA	Not Applicable
PDD	Program Description Document
PRC	Program Review Committee
SAC	Specific Administrative Control
SRMS	Safety Requirement Management System
SRNL	Savannah River National Laboratory
TCCR	Tank Closure Cesium Removal
TSR(s)	Technical Safety Requirement(s)

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1.0 Purpose

The purpose of this Program Description Document is to provide guidance to Engineering personnel for implementing controls contained within the Documented Safety Analysis (DSA) programs and Technical Safety Requirements (TSR) Administrative Controls for the Tank Closure Cesium Removal (TCCR) Operations Program. The TCCR Operations Program supports TCCR feed batch qualification of Tank 10 material and protects assumed initial conditions during TCCR Unit processing.

2.0 Scope

The scope of the TCCR Operations Program includes the salt solution feed tank (Tank 10), transfer systems to feed the TCCR Process Enclosure, and the TCCR Process Enclosure. Preparation of salt solution batches for feed to TCCR are covered under other existing programs. Salt solution batches are qualified under the TCCR Operations Program. Once a salt solution batch is qualified, the TCCR Operations Program provides requirements and actions needed to maintain qualification until the salt solution batch has completed processing. The TCCR Operations Program also establishes requirements to ensure adequate passive cooling by the TCCR Ion Exchange (IX) Column Water Jacket and draining of the IX Columns prior to removal from the TCCR Process Enclosure.

3.0 Background

3.1 TCCR Process Description – Summary

The TCCR Unit decontaminates dissolved saltcake (hence forward referred to as salt solution or supernate) by removing cesium using an ion exchange resin called UOP IONSIV R9120-B©, a form of crystalline silicotitanate (CST). CST was developed to selectively remove cesium from alkaline salt solution (Ref. 1) and has some removal capabilities for strontium and actinides, but to a lesser extent than cesium. The extent to which CST removes cesium is dependent upon multiple factors including the temperature and composition of the feed material. Lower temperatures and the lack of competing ions favor cesium removal from salt solution. Anion chemistry also effects cesium loading. Very high cesium loading on CST results in higher radiolytic decay heat (from Cs-137) being produced within the column. Performance of the TCCR SAC ensures that Cs-137 loading is less than the TSR limit of 293 Ci of Cs-137 per kg of CST (Ref. 2). This limit ensures that insufficient decay heat is available within the column to self-heat to a boiling temperature. Pre-filters protect

the IX Columns from solids that could cause pluggage. A resin trap downstream of the IX Columns captures resin in the column effluent on its flow path to Tank 11. Preparation of salt solution is performed by adding a solvent, typically water or water inhibited with sodium hydroxide and sodium nitrite, to a waste tank containing saltcake. Mixing the solvent using recirculation (via multiple [3] return lines) facilitates salt dissolution by reducing density gradients within the liquid phase. Engineering flowsheets typically specify the conditions, limits and requirements for performing salt dissolution activities in high level waste tanks, including considerations for waste tank corrosion and flammability. Mixing will continue until the salt solution specific gravity, typically measured by dip tubes, becomes relatively constant indicating the endpoint of salt dissolution for the batch or facility management/engineering determine that sufficient salt dissolution has occurred. Typically, water will be added to dissolve saltcake in multiple batches.
A means to measure cesium loading onto CST has been developed. This test, henceforward referred to as the Batch Equilibrium Contact Test, shall be performed for each salt solution batch. This is done to ensure that the cesium loading onto the CST will not result in sufficient radiolytic decay heat to reach the column solution's boiling temperature assumed to be 100°C (Ref. 2). Once the loading has been confirmed, TCCR operations may begin for that batch. Each subsequent batch of salt solution must be tested to confirm loading prior to feeding the TCCR Unit. TCCR Ion Exchange (IX) Columns will typically be configured in a lead-lag arrangement. The lead column will be taken off-line once in-line radiation monitors indicate cesium break through or management/engineering deem the column loaded. The lag column will be placed in the lead position and a new IX column put on line in the lag position. This will continue until completion of salt removal for Tank 10. Loaded columns will be flushed with a solution of sodium hydroxide and water, then drained by pressurized air. The IX Column will then be purged with air to dry the resin media prior to removal from the TCCR Process Enclosure and transported to Interim Safe Storage (ISS).

3.2 TCCR Operations Program (SS) (SAC)

The TCCR Operations Program is a Safety Significant Specific Administrative Control credited in the following DSA Chapter 3 accidents:

- Tornado and High Winds Event (Section 3.4.2.17)
- Seismic Event (Section 3.4.2.18)
- Wildland Fire (Section 3.4.2.19)
- Tank Closure Cesium Removal Events (Section 3.4.2.23)

During normal operations, liquid waste in the TCCR Unit is maintained well below boiling temperatures. However, IX Columns inside the TCCR Unit concentrate radionuclides from Tank 10 feed material which will result in thermal heating. Over-pressurization and overheating may occur from excessive thermal loading as well as from external fires. A breach in the IX column is considered possible if the internal pressure in the IX column exceeds the design pressure which could result in an airborne waste release. In the mitigated accident progression, the TCCR Operations Program is the first level of control which protects both the over-pressurization due to self-heating and over-pressurization due to external sources of fire events (e.g. wildland fire, combustible fueled engines and containers).

In the IX Column Pressurized Release event, the TCCR Operation Program protects the assumed initial conditions by 1) ensuring that the Cs-137 loading within the column is within analyzed limits and 2) ensuring that the liquid level in the IX Column Water Jacket is at or above the top of the resin within the column. Other elements of the TCCR Operations Program protect column loading limits through successful qualification of the salt solution feed batch to the TCCR Unit, and protection of the qualified batch starting at the point in time that the resin test vials are deployed until completion of the salt solution feed batch processing.

In the Transportation Fire Column Release event, the TCCR Operations Program protects the assumed initial condition of less than 25% of the IX Column's liquid inventory is present within the column. The TCCR Operations Program requires that the IX Columns be reduced in liquid inventory by air blowing the column's liquid to either Tank 10 or Tank 11. An air blow is necessary as the IX Column outlet line is above the top of the column and air is needed to force the liquid from the bottom of the column upward through the exit line. Cameras installed in the receipt tank (Tank 10 or 11) monitor the flow of liquid from the column into the receipt tank. Successful liquid inventory reduction is achieved when the flow of liquid into the receipt tank slows to no visible liquid exiting the receipt tank's inlet hose.

4.0 TCCR Operations Program (SAC) Description

The TCCR Operations Program shall be established to support TCCR feed batch qualification, control vehicle/fuel requirements near the TCCR Unit, and protects assumed initial conditions during TCCR Unit processing. The program shall at a minimum include the following (Ref. 3):

1. Transfers of waste are prohibited to Tank 10 excluding transfers from the TCCR Unit and Tank 10 Contingency Transfer System transfers.

The TCCR waste streams, and associated inhalation dose potentials, are based on Reference 4 and the accident analyses associated with the TCCR Unit did not analyze additional waste material being transferred to Tank 10.

2. Prior to initiating Tank 10 recirculation, the Tank 10 Transfer Pump Discharge Three-way Valve shall be aligned to Tank 10.

3. When the Tank 10 Transfer Pump Discharge Three-Way Valve is aligned to the TCCR Unit, operation of the Tank 10 transfer pump is prohibited from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch has been qualified.

4. Waste tank recirculation of Tank 10 is prohibited from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.

   Backflush of the TCCR pre-filters or flow through the Tank 10 transfer pump minimum flow return line are not considered waste tank recirculation for compliance with this requirement. If waste tank recirculation occurs during the prohibition period, the Batch Equilibrium Contact Test is invalidated.

5. Prior to transfer initiation to the TCCR Unit, perform a Batch Equilibrium Contact Test and verify the Cs-137 loading is less than or equal to 293 Ci of Cs-137 per kilogram of CST.

   A Batch Equilibrium Contact Test will be performed on each TCCR feed batch and the analytical results will be compared to the limit via an engineering evaluation. The test and engineering evaluation shall be based upon the methodology of Reference 1, and the test shall be performed using at least two in-tank samples (resin test vials).

   The limit is derived via References 1 and 5 (293 Ci of Cs-137 per kilogram of CST) and accounts for penalties associated with Items 12 and 13 of the TCCR Operations Program (liquid additions and IX column flushes to Tank 10). However, the engineering evaluation shall consider the following penalties and error terms for comparison against the limit:

   - An analytical uncertainty of 2 Sigma shall be included on the laboratory reported results for Cs-137 when comparing against the limit.

- An 18% error term shall be added to the laboratory reported results for Cs-137 when comparing against the limit. This error term is in addition to the 2 Sigma analytical uncertainty applied.
- One of the following temperature decrease penalties shall be added to the laboratory reported results for Cs-137 when comparing against the limit:
    - A bounding penalty of 57 Ci of Cs-137 per kilogram of CST (to allow a $5^{O}C$ variance [decrease] of the Tank 10 temperature), or
    - An engineering evaluation derived penalty assessing a conservative temperature variance based on the Tank 10 waste temperature at the end of the Batch Equilibrium Contact Test period (when the resin test vials are removed from the tank).

If a TCCR feed batch does not meet the requirements of the Batch Equilibrium Contact Test, the batch must be remediated and tested again prior to transfer initiation to the TCCR Unit.

6. Prior to transfer initiation to the TCCR Unit, determine and document the Tank 10 TCCR feed batch temperature limit (derived from the Batch Equilibrium Contact Test) in the ERD.

   The Tank 10 TCCR feed batch temperature limit shall be based on the Tank 10 waste temperature at the end of the Batch Equilibrium Contact Test period (when the resin test vials are removed from the tank) and shall account for instrument uncertainties. To ensure an accurate waste temperature indication, the elevation of the temperature element shall be within the supernate level in the waste tank.

7. Prior to transfer initiation to the TCCR Unit, ensure the TCCR feed batch supernate nitrite concentration in Tank 10 is greater than or equal to 0.0275 M.

   The minimum nitrite concentration in waste tank supernate shall be maintained greater than or equal to 0.0275 M (this value accounts for analytical uncertainty) to effectively eliminate the corrosion, radiolysis of organics, and catalyst mechanism as flammability concerns, as discussed in Reference 2.

8. Prior to transfer initiation of initial waste feed to the TCCR unit and every 300 days thereafter, ensure the TCCR IX Column Water Jackets are filled to overflow with water.

   This control is no longer required (on an individual IX Column) once at least two vent paths are established on the IX Column. The 300-day periodic water jacket refill is based on Reference 6.

9. Prior to transfer initiation to the TCCR Unit, verify Tank 10 waste temperature is greater than or equal to the Tank 10 TCCR feed batch temperature limit. During transfers to the TCCR Unit, verify Tank 10 waste temperature is greater than or equal the Tank 10 TCCR feed batch temperature limit every 7 days.

   The Tank 10 TCCR feed batch temperature limit is documented in the ERD (Ref. 7), per item 6 of the TCCR Operations Program. The 7-day periodic check of waste temperature is based upon expected operating conditions in Tank 10 and supported by historical Tank 10 temperature measurements (Ref. 1). To ensure an accurate waste temperature indication, the elevation of the temperature element shall be within the supernate level in the waste tank.

10. Combustible fueled (e.g., gasoline, diesel, propane) engines and fuel containers shall not be present within 20 feet of the TCCR Process Enclosure during operations of the TCCR Unit (i.e., feed being provided to the TCCR Unit), excluding attended combustible fueled (e.g., gasoline, diesel, propane) engines and fuel containers totaling less than or equal to 6 gallons.

11. Vehicle barriers (e.g., jersey barriers) shall be established between areas of vehicle access and the TCCR Process Enclosure during operations of the TCCR Unit (i.e., feed being provided to the TCCR Unit).

12. Liquid additions to Tank 10 shall be limited to less than or equal to 3,000 gals. (or dilution volume limit determined by engineering evaluation) for each TCCR feed batch. This control is applicable from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.

    If an engineering evaluation is used to increase the dilution volume limit, the evaluation shall be based upon the methodology of Reference 1 using existing waste tank conditions (including consideration of previous liquid additions for the TCCR feed batch). If liquid additions to Tank 10 exceed the volume limit, the Batch Equilibrium Contact Test is invalidated.

13. IX Column flushes to Tank 10 shall be limited to two flushes, (or IX Column flush limit determined by engineering evaluation) for each TCCR feed batch. This control is applicable from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin

test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.

If an engineering evaluation is used to increase the permitted IX Column flushes, the evaluation shall be based upon the methodology of Reference 1 using existing waste tank conditions (including consideration of previous column flushes for the TCCR feed batch). If IX Column flushes to Tank 10 exceed the limit, the Batch Equilibrium Contact Test is invalidated.

Automatic venting of the IX Columns does not count towards the two-column flush limitation, as this automatic cycling is a short duration (e.g., seconds) and has negligible impact on bulk chemistry.

14. Prior to initiation of flow for multiple IX Column series operation (i.e., lead/lag configuration), ensure the lead column is flushed with greater than or equal to 150 gallons of liquid (e.g., feed, flush water, caustic) to Tank 10 or Tank 11.

    This requirement is not applicable to the process flow interruptions due to TCCR pre-filter back-flushes or placing a new, unloaded IX Column in service in the lead position.

15. Prior to removal of an IX Column from the TCCR Process Enclosure, the IX column liquid inventory shall be reduced (using pressurized air) until no liquid is observed exiting the transfer line to Tank 10.

    The term “no liquid flow is observed exiting the transfer line” is intended to mean that the majority of the liquid has been removed from the IX Column during the de-inventory process and is primarily verified by the liquid to air transition verification discussed in Section 5.5.4.2.53.4 of Reference 2. Continuous flow of liquid should not be observed after this process; however, liquid dripping from the transfer line back to the tank is permitted. This requirement protects the DSA assumed initial condition of no more than 25% of the liquid inventory remaining in the IX Column.

To effectively implement the TCCR Operations Program, three phases are established to sequence the various TCCR operations and associated SAC attributes. These phases are; Batch Prep, Sample and Qualified. The ERD is the tool by which phases are changed at the appropriate point in time; operating procedures provide direction to Operations to invoke the associated SAC attributes which are required during that particular phase. A brief explanation of each phase follows:

Batch Prep: During Batch Prep, Engineering authorizes the addition of water for salt dissolution in Tank 10 in accordance with the Waste Tank Flammability Program (Ref. 8) and Corrosion Control Program (Ref. 9). The Tank 10 Transfer Pump Discharge Three-way Valve is positioned to Tank 10 to permit recirculation to facilitate salt dissolution. Recirculation is terminated based upon specific gravity measurement or determination by facility management or engineering that dissolution is complete.

Sample: During the Sample phase, salt solution samples are obtained and two resin test vials are deployed into Tank 10. Recirculation is prohibited during the Sample phase; the Tank 10 Transfer Pump Discharge Three-way Valve is aligned to the TCCR Unit in the transition from Batch Prep to Sample and operation of the Tank 10 Transfer Pump is prohibited. During the Sample phase, the salt solution temperature is recorded, and the resin test vials are retrieved and sent to SRNL for Cs-137 determination. Results of the analysis of the salt solution samples and resin are used as inputs to qualify the salt batch as feed to the TCCR Unit. Liquid additions to Tank 10 and IX Column flushes to Tank 10 must be tracked during the Sample phase since compositional changes must be accounted for once the resin test vials have been deployed.

Qualified: During the Qualified phase, the TCCR feed batch qualification process has completed and initiation of feed to the TCCR Unit is approved. Liquid additions to Tank 10 and IX Column Back-flushes to Tank 10 must continue to be tracked and limited as specified by the TCCR Feed Batch Qualification Report or engineering evaluation and ERD. Compliance with the TCCR feedbatch qualification temperature limit is also required during the Qualified phase. It is permissible to change the Tank 10 Transfer Pump elevation while in the Qualified phase provided that the new elevation is in alignment with the engineering evaluation that documents protection of the minimum supernate volume of 15,000 gals. See Section 6.0 attribute 12 for implementation requirements when altering the Tank 10 Transfer Pump while in the Qualified phase.

Appendix A provides a more detailed list of activities to present an overview of the expected sequence of activities within each phase. The list in Appendix A is provided as an illustration and is not intended to prescribe operations.

Implementation actions for each of the program requirements above are summarized in section 6.0. Description of the Batch Equilibrium Contact Test and engineering evaluations that support qualification of a salt batch are contained in Section 4.2.

4.1 Batch Equilibrium Contact Test

Each TCCR feed batch must be qualified prior to initiating feed to the TCCR Unit. This qualification ensures that the IX Column's Cs-137 loading remains within limits.

Additionally, parameters that must be maintained during feed batch processing are identified and documented in the qualification report.

4.1.1 Loading Limit: The CST Facilities DSA establishes a loading limit of 293 Ci of Cs-137 per kg of CST. This limit protects an assumed IX Column boiling temperature of 100°C and includes penalties associated with two IX column flushes to Tank 10 and up to 3,000 gals. of liquid additions to Tank 10. Additional penalties must also be applied to the loading limit to account for temperature decrease during TCCR operations, loading bias for the Batch Equilibrium Contact Test, and two Sigma analytical uncertainty. Additional flushes and or liquid additions and their associated penalties are allowed by engineering evaluation. The Batch Equilibrium Contact Test is required to confirm that the pending salt solution batch will not load above the established limit.

4.1.2 Batch Equilibrium Contact Test Description: The Batch Equilibrium Contact Test is an in-tank test where a small mass of CST resin (~ 0.1 g) is placed in a resin test vial and deployed into the salt solution batch in Tank 10. A minimum of two resin test vials are required for each Batch Equilibrium Contact Test in order to establish a statistical uncertainty for the measured results. The test vials are prepared by SRNL in accordance with Task Technical Quality Assurance Plan for In-Tank Batch Contact Testing in Support of Tank Closure Cesium Removal (Ref. 10) and laboratory procedures. The two test vials are lowered into the Tank 10 salt solution and remain suspended in the salt solution for a minimum of 10 days (Ref. 1). After 10 days, the resin test vials are retrieved and transported to SRNL for Cs-137 loading determination. During resin test vial retrieval, the salt solution temperature is recorded and will be used for determining the lower temperature limit during TCCR operations. Though not a part of the Batch Equilibrium Contact Test, the nitrite concentration of the salt solution batch will also be verified to be equal to or greater than 0.0275 M by normal dip sampling methods. Engineering evaluations may be used to confirm the minimum nitrite concentration using sample results and subsequent tank additions.

4.1.3 Batch Equilibrium Contact Test Qualification Documentation: SRNL will measure and report the Cs-137 loading per kg of CST, including measurement uncertainty in a technically reviewed (E7 procedure 2.60) memo/report. SRR Engineering will prepare a technical report

documenting the successful qualification of the salt batch, i.e., meets the Cs-137 loading limit, the number of allowable IX Column flushes to Tank 10, allowable water addition volume, nitrite concentration greater than 0.0275 M, lower temperature limit for the salt batch and completion of the Tank 11 pre-transfer impact evaluation. The report shall also confirm that the Tank 10 transfer pump suction elevation protects the assumed minimum volume of Tank 10 salt solution (15,000 gallons) and that the specified temperature element used to monitor the feed batch temperature remains within the liquid phase throughout processing of the feed batch. The ERD (Ref. 7) will be updated for each newly qualified salt batch and processed by Operations for field implementation. Operating procedures shall confirm prior to initiating feed to the TCCR Unit that the salt solution batch has been qualified and that the associated feed batch processing requirements (i.e. temperature limit, number of flushes to Tank 10, temperature element and liquid addition volume) are properly reflected in procedures and/or the Morning Report.

If analysis of the CST test vials results in a Cs-137 loading that is above the limit, then the batch must be remediated and retested. Remediation may include chemical additions designed to reduce cesium loading by adding ion exchange competitors to the TCCR feed batch. An engineering evaluation will document the required remediation action(s).

4.2 Engineering Evaluations Supporting Salt Batch Qualification.

Output documents generated in response to this Program Description Document shall meet the requirement of E7 - Conduct of Engineering Manual.

Reference 1 documents the methodology for determining the adjustments or "penalties" to the Cs-137 loading limit for qualifying a batch of salt solution. Reference 1 utilizes conservative assumptions and inputs applicable to all projected batches of TCCR feed from Tank 10. These inputs and assumptions are further discussed in section 5.2.1 and 5.2.2 of Reference 1. The resulting analysis establishes conservative values for each type of penalty to be applied for the salt batch. Conversely, an engineering evaluation may be performed to specify the applicable values for the different penalties using the methodology of Reference 1. Section 5.2.3 through 5.2.5 describes each type of penalty and the methodology for engineering evaluations in lieu of the default penalties of Reference 1.

4.2.1 Inputs Used in Engineering Evaluations Supporting TCCR Feed Batch Qualification (Ref. 1)

4.2.1.1 Table 1 is used to determine Cs-137 loading increase due to reduced salt solution feed temperature.

Table 1. ZAM Model Loading Predictions (Ref. 1)

Temperature (°C)	Loading (mmol of Cs/g $_{CST}$)
20	0.1025
23	0.0951
24	0.0927
25	0.0905
26	0.0882
27	0.0861
28	0.0840
29	0.0819
30	0.0799
31	0.0780
32	0.0761
33	0.0743
34	0.0725
35	0.0707
37	0.0674
39	0.0642
40	0.0627

4.2.1.2 Two Sigma Uncertainty is Added to the Cs-137 loading results from the Batch Equilibrium Test CST samples. This is a required attribute of the TCCR Operations Program SAC.

4.2.1.3 Assignment of Error for In-Tank Batch Qualification Testing is 18%.

The resin test vials immersed in the Tank 10 salt solution will not be subject to continuous motion. Laboratory batch equilibrium contact tests provide a sample with continuous mixing to avoid a localized depletion of cesium in the salt solution surrounding the CST. The 18% correction factor is added to the measured Cs-137 loading results after application of the two Sigma uncertainty.

4.2.1.4 Conversion Factors (Ref. 1)

1 gallon (gal.) = 3.785 liters (l)
1 kilogram (kg) = 1000 grams (g)
1 liter = 1000 milliliters (mL)
1000 milligram (mg) = 1 gram
1 millimole (mmol) = 0.001 mole (m)
Molecular weight of Cs-137 = 137 g per gmole
Specific Activity of Cs-137 = 86.98 Ci per g

4.2.2 Assumptions Used In Engineering Evaluations

Reference 1 identifies the assumptions used for determining Cs-137 loading penalties.

4.2.3 Engineering Evaluation of IX Column Flushes to Tank 10

IX Column Back-flushes to Tank 10 must be evaluated for penalty to the IX Column loading limit due to the additional cesium that is desorbed from the CST within the IX Column and returned to Tank 10 thus increasing the overall Cs-137 concentration for the associated feed batch. Once feed flow through the column has stopped, decay heat from the loaded CST will increase the resident fluid temperature resulting in a release of cesium from the resin. This is due to the adsorption process being exothermic, and thus an increase in fluid temperature will drive the equilibrium away from adsorption (Ref. 1).

The IX Column loading limit of 293 Ci of Cs-137 per kilogram of CST includes the penalty associated with two IX Column flushes in accordance with Ref. 1. Two column flushes result in a penalty of 16 Ci of Cs-137

per kilogram of CST for each flush for a total of 32 Ci of Cs-137 per kg of CST. Additional flushes are permitted provided an engineering evaluation is performed and further reduces the maximum Cs-137 loading limit per kilogram of CST by 16 Ci for each additional flush. The resulting loading limit must then be compared to the Batch Equilibrium Contact Test results and shown to be less than the measured Cs-137 Ci per kilogram of CST loading value, including associated penalties described in sections 5.2.3, 5.2.4 and 5.2.5 of Reference 1.
Note: IX Column flushes to Tank 11 do not impact the TCCR feed batch and therefore do not require adjustment to the batch qualification limit. However, the impact of the elevated Cs-137 concentration in the flush material shall be considered for impact on Tank 11 and downstream processes.

4.2.4 Engineering Evaluations of Liquid Additions to Tank 10

Liquid additions to Tank 10 must be evaluated for penalty to the IX Column loading limit due to their dilution effect on sodium, one of the prime competitors with cesium for CST loading. The IX Column loading limit of 293 Ci of Cs-137 per kilogram of CST includes the penalty associated with 3,000 gals. of liquid addition to Tank 10 per TCCR feed batch (Ref. 1), which is 12 Ci of Cs-137 per kilogram of CST. The 3,000 gals. limit is determined by protecting a 20% dilution assuming a minimum liquid volume of 15,000 gallons in Tank 10. The 15,000 gals. minimum liquid volume is protected by placing the Tank 10 transfer pump suction at a minimum elevation above the saltcake layer as specified by engineering evaluation (see section 6.0 Attribute 12 for additional information on protecting the minimum salt solution volume). Since a minimum liquid volume is protected, the liquid additions may be made at any time throughout processing of the TCCR feed batch. Only liquid additions made after initiation of the Batch Equilibrium Contact Test count towards the 3,000 gallons limit.

The 3,000 gals. limit may be increased if approved by an engineering evaluation. Since the Tank 10 transfer pump suction elevation is required to protect a minimum of 15,000 gals. of salt solution, the engineering evaluation is applicable for a one-time addition to Tank 10 based upon the current salt solution volume in Tank 10 and prior liquid additions to the TCCR feed batch. The engineering evaluation must also establish the

remaining available liquid additions applicable for the TCCR feed batch following the one-time addition. To establish the current salt solution volume in Tank 10, feed to the TCCR Unit must be secured until completion of the engineering evaluation and the required Morning Report and procedure changes for any remaining liquid additions implemented. The engineering evaluation is performed in accordance with Table 2 and follows the guidelines of Ref. 1.

Table 2. Steps for Performing the Engineering Evaluation to Allow Greater than 3,000 Gallon Liquid Addition to Tank 10H During Salt Batch Processing (Ref. 1)

Step Number	Steps
1	Obtain the volume of liquid additions that have been added to Tank 10H.
2	Determine the salt solution volume in Tank 10H*.
3	Reduce the Tank 10H salt solution volume by 2,710 gallons** for added conservatism.
4	Multiply the salt solution volume determined in Step 3 by 0.2.
5	Subtract the values obtained in Step 1 from Step 4. This is the maximum allowable liquid addition volume that can be added to Tank 10H at its current salt solution volume. If a negative value for the volume is obtained, no addition can be made.
6	Subtract 300 gallons from the liquid addition volume determined in Step 5, this results in the allowable volume. The 300 gallons** is selected to ensure the liquid addition volume determined in Step 5 cannot be exceeded. If a negative value for the volume is obtained, no addition can be made.
7	After the liquid addition is complete, record the volume added to Tank 10H. No further liquid additions can be made without an engineering evaluation once TCCR processing is resumed.
8	If a second (or subsequent) bulk liquid addition is required, perform an engineering evaluation follow Steps 9 through 15.
9	Is the level in Tank 10H greater than or equal to the first (or prior) evaluation? If yes, see below. If no, go to Step 10. • Go to first (or prior) evaluation and determine if the total allowable liquid addition volume amount has been used. If yes, no further liquid additions are allowed. If no, determine the delta volume amount of liquid addition that is allowable from the first evaluation. This is determined by subtracting the liquid addition volume added to Tank 10H from the maximum allowable liquid addition volume calculated in the evaluation (See Ref. 1 Appendix F, Case 1). No further liquid additions are allowed beyond this volume.

10	Determine the % dilution that has been performed to Tank 10H. All previous evaluations must be used for each individual salt batch for this determination. (See Reference 1 Appendix F, Case 2.)
11	Subtract the percentage determined in Step 10 from 20%. This is the new allowable dilution percent for Tank 10H.
12	Determine the salt solution volume in Tank 10H*. Reduce the Tank 10H volume by 2,710 gallons** for added conservatism.
13	Multiply the salt solution volume determined in Step 12 by the new allowable dilution percent divided by 100 determined in Step 11. This is the maximum allowable liquid addition volume that can be added to Tank 10H at its current level.
14	Subtract 300 gallons from the value determined in Step 13, this results in the allowable volume. The 300 gallons** is selected to ensure the liquid addition volume determined in Step 13 cannot be exceeded. If a negative value for the volume is obtained, no addition can be made
15	After the liquid addition is complete, record the volume added to Tank 10H. No further liquid additions can be made without an engineering evaluation once TCCR processing is resumed.

*Assumes TCCR is not in production and is shut down in-order to complete the engineering evaluation.

**These volumes protect the 20% from being exceeded. These can be adjusted based on engineering judgement.

An engineering evaluation[1] may also be performed to reset the "volume allowance" for additions of liquid at any level above 15,000 gallons, once the initial 3,000 gallons liquid addition volume limit is expended or forecast to be expended by a planned addition. The new "volume allowance" is allowed if the liquid additions do not exceed 20% of the current volume of salt solution in Tank 10H. The engineering evaluation must include all liquid additions made previously to the current salt batch in Tank 10H and must account for a reduction of 3,010 gallons[2] (2710 gallons + 300 gallons) to the current or lowest level (per last engineering evaluation[3]) in Tank 10H when calculating the remaining percentage of the 20% dilution. If the remaining percentage is greater than zero, this percentage can then be multiplied by 15,000 gallons to obtain the new "volume allowance" for liquid additions at any level above 15,000 gallons.

[1] Assumes TCCR is not in production and is shut down in-order to complete the engineering evaluation.
[2] The reduction in volume accounts for uncertainty in the Tank 10H level measurement (2710 gallons) as well as other uncertainty in the water additions (300 gallons). This volume protects the 20% from being exceeded.
[3] If a 3,000 gallons liquid addition has been made to the starting volume of the salt batch and no processing through TCCR has been completed, the starting volume of the salt batch must be used.

Exceeding the liquid addition limit invalidates the TCCR feed batch qualification.

4.2.5 Engineering Evaluation of TCCR Feed Batch Temperature Limit

It has been demonstrated previously through batch equilibrium contact testing that CST loading in alkaline solutions is temperature dependent, where equilibrium loading decreases with increasing salt solution feed temperature (Ref. 1). Therefore, the temperature during the In-Tank Batch Equilibrium Loading Test is important and must be recorded just prior to removal of the resin vials from Tank 10. Since the CST loading will be closest to equilibrium at the end of the test, the temperature at this point is most applicable to the engineering evaluation and is used to establish the lower temperature limit during processing of the TCCR feed batch.

There are two sources of penalties related to temperature; 1) temperature measurement uncertainty and 2) changes in salt solution feed batch temperature during TCCR operation. Reference 1 evaluates the impact of both measurement uncertainty (3°C, Ref. 11) and salt batch feed temperature changes (assumed to be less than or equal to 2°C) with a resulting penalty of 43.47 Ci of Cs-137 per kilogram of CST based upon the assumed lowest expected feed temperature of 20°C. This penalty is further increased by 30% as a ZAM model correction factor to a final penalty of 57 Ci of Cs-137 per kilogram of CST.

In lieu of the conservative default temperature penalty of 57 Ci of Cs-137 per kilogram of CST, an engineering evaluation may be performed utilizing the methodology of Ref. 1. In this situation, the engineering evaluation uses the Batch Contact Equilibrium Test temperature rather than the assumed value of 20°C that is used in the default case. Additionally, the engineering evaluation may also establish an assumed temperature drop for the TCCR feed batch different than the 5°C used in Ref. 1. The assumed temperature drop shall include both instrument uncertainty effects and anticipated temperature changes in Tank 10. Using the information from Table 1, the loading increase is determined based upon the recorded In-Tank Batch Contact Equilibrium Test temperature and the assumed temperature reduction. Non-whole number values for the

temperature are rounded down for use in Table 1. If the lowest anticipated tank temperature is not in Table 1, then use the next lower temperature. The loading increase from Table 1 is converted from mmoles of Cs-137 per gram of CST to grams of Cs-137 per gram of CST and from grams of Cs-137 per gram of CST to Ci using the Cs-137 Specific Activity (86.98 Ci per gram). This result is then converted to grams of Cs-137 per kg of CST for consistency of units with the SAC limit. The ZAM model correction factor of 30% is then applied to arrive at the final temperature penalty.

5.0 Interfaces with Other Programs

5.1 Waste Tank Flammability Program: Liquid additions and Salt Dissolution activities in Tank 10 shall meet the requirements of the Waste Tank Flammability Program (Ref. 8).

5.2 Corrosion Control Program: Liquid additions and Salt Dissolution activities in Tank 10 shall meet the requirements of the Corrosion Control Program (Ref. 9).

5.3 Fire Protection Program: Combustible loading within the TCCR Process Enclosure shall be controlled in accordance with the Fire Protection Program (Ref. 3).

5.4 Transfer Control Program: Determination of the equipment to stop transfer, verification of available tank space, and a VFD speed check shall be controlled in accordance with the Transfer Control Program (Ref. 12).

5.5 Configuration Management Program: Placement of the Tank 10 Transfer Pump suction shall meet the requirements of the Configuration Management Program (Ref. 3).

5.6 General: Prior to initiation of feed to the TCCR Unit, an engineering evaluation assessing the impacts of the processed feed batch on Tank 11 shall be performed. This impact evaluation is performed in lieu of an Electronic Transfer Evaluation Form (ETAF) which is used for waste tank to waste tank transfer impact analysis. The TCCR Feed Batch Qualification Report verifies completion of the impact evaluation.

6.0 Summary of Implementation Actions for the TCCR Operations Program: Each attribute of the TCCR Operations Program is listed below (italics) with its associated implementation action(s).

1. *Transfers of waste are prohibited to Tank 10, excluding transfers from the TCCR Unit and Tank 10 Contingency Transfer System Transfers.*

   The TCCR waste streams, and associated inhalation dose potentials, are based on Reference GG (Ref. 13) *and the accident analyses associated with the TCCR Unit did not analyze additional waste material being transferred to Tank 10.* (Ref. 3, Sect. 5.8.2.57 Attribute a.)

   No other transfer lines are available either into or out of Tank 10 other than those associated with TCCR waste transfers and the Tank 10 Contingency Transfer System transfers. This attribute is controlled by the Configuration Management Program and performance of the USQ process.

2. *Prior to initiating Tank 10 recirculation, the Tank 10 Transfer Pump Discharge Three-way Valve shall be aligned to Tank 10.* (Ref. 3, Sect. 5.8.2.57 Attribute b.)

   This attribute is implemented by Operating procedures.

   Prior to transfer initiation of the Tank 10 Transfer Pump for the purposes of waste tank recirculation, independent verification of the Tank 10 Transfer Pump Discharge Three-Way Valve alignment (aligned to Tank 10) shall be completed. After initiating the transfer, verify recirculation flow occurs into Tank 10 via inspection camera.

3. *When the Tank 10 Transfer Pump Discharge Three-Way Valve is aligned to the TCCR Unit, operation of the Tank 10 transfer pump is prohibited from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch has been qualified.* (Ref. 3, Sect. 5.8.2.57 Attribute c.)

   This attribute is implemented in Operating procedures. Prior to deploying the resin test vials, Operating procedures shall confirm that the Tank 10 Transfer Pump is de-energized and Administrative Control locked in that position and that the Tank 10 Transfer Pump Discharge Three-Way Valve is aligned to the TCCR Unit. Independent verification

confirming alignment of the Tank 10 Transfer Pump Discharge Three-way Valve shall be performed.

4. *Waste tank recirculation of Tank 10 is prohibited from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.*

   Backflush of the TCCR pre-filters or flow through the Tank 10 Transfer Pump minimum flow return line are not considered waste tank recirculation for compliance with this requirement. If waste tank recirculation of Tank 10 occurs during the prohibition period, the Batch Equilibrium Contact Test is invalidated. (Ref. 3, Sect. 5.8.2.57 Attribute d.)

   This attribute is implemented in conjunction with attribute #3 in Operating procedures, which includes Independent Verification of the Tank 10 Transfer Pump Discharge Three-Way Valve. Additionally, after initiating transfer to the TCCR Unit, Operating procedures shall verify by inspection camera that no recirculation occurs in Tank 10.

5. *Prior to transfer initiation to the TCCR Unit, perform a Batch Equilibrium Contact Test and verify the Cs-137 loading is less than or equal to 293 Ci of Cs-137 per kilogram of CST.*

   A Batch Equilibrium Contact Test will be performed on each TCCR feed batch and the analytical results will be compared to the limit via an engineering evaluation. The test and engineering evaluation shall be based upon the methodology of Reference HH (Ref. 5)*, and the test shall be performed using at least two in-tank samples (resin test vials).*

   The limit is derived via References HH (Ref. 1) *and DD* (Ref. 5) *(293 Ci of Cs-137 per kilogram of CST) and accounts for penalties associated with Items 12 and 13 of the TCCR Operations Program (liquid additions and IX column flushes to Tank 10). However, the engineering evaluation shall consider the following penalties and error terms for comparison against the limit:*

   - *An analytical uncertainty of 2 Sigma shall be included on the laboratory reported results for Cs-137 when comparing against the limit.*
   - *An 18% error term shall be added to the laboratory reported results for Cs-137 when comparing against the limit. This error term is in addition to the 2 Sigma analytical uncertainty applied.*
   - *One of the following temperature decrease penalties shall be added to the laboratory reported results for Cs-137 when comparing against the limit:*

- *A bounding penalty of 57 Ci of Cs-137 per kilogram of CST (to allow a 5°C variance [decrease] of the Tank 10 temperature), or*
- *An engineering evaluation derived penalty assessing a conservative temperature variance based on the Tank 10 waste temperature at the end of the Batch Equilibrium Contact Test period (prior to removing the resin test vials).*

If a TCCR feed batch does not meet the requirements of the Batch Equilibrium Contact Test, the batch must be remediated and tested again prior to transfer initiation to the TCCR Unit. (Ref. 3, Sect. 5.8.2.57 Attribute e.)

Results of the Batch Equilibrium Contact Test are documented in an SRNL memo/report which has been reviewed in accordance with E7 Procedure 2.60. This memo/report is then used as input to the TCCR Feed Batch Qualification Report. The TCCR Feed Batch Qualification Report shall include the Cs-137 loading result and associated penalties, the water addition volume limit, the number of allowed IX Column flushes to Tank 10, the salt batch temperature lower limit, and confirmation that the minimum nitrite limit has been met. (Ref. 5). The application of the 18% error term shall be applied to the Cs-137 loading result plus the 2-sigma analytical uncertainty. Results of the TCCR Feed Batch Qualification Report that require implementation into Operating procedures are listed in the ERD. Operating procedures shall verify that the feed batch is qualified prior to initiating feed to the TCCR Unit.

6. *Prior to transfer initiation to the TCCR Unit, determine and document Tank 10 TCCR feed batch temperature limit (derived from the Batch Equilibrium Contact Test) in the ERD (Ref. 46)* (Ref. 7).

   The Tank 10 TCCR feed batch temperature limit shall be based on the Tank 10 waste temperature at the end of the Batch Equilibrium Contact Test period (when the resin test vials are removed from the tank) and shall account for instrument uncertainties. To ensure an accurate waste temperature indication, the elevation of the temperature element shall be within the supernate level in the waste tank. (Ref. 3, Sect. 5.8.2.57 Attribute f.)

   The temperature at the end of the Batch Equilibrium Contact Test is recorded in operating procedures during the process of removal of the resin test vials from Tank 10. Temperature measurements shall be performed locally at Tank 10 using the Altek Universal Thermocouple Calibrator Model 422 as the Measuring and Test Equipment (M&TE). Engineering determines the associated temperature penalty to be applied to the TCCR feed batch (see section 5.2.5 of Reference 1) including instrument uncertainty

(Ref. 11) and documents the temperature limit in the TCCR Feed Batch Qualification Report and ERD. Implementation of the ERD associated with the TCCR Feed Batch Qualification Report updates the feed batch temperature limit in operating procedures.

Engineering shall specify the thermocouple loop that will be used to monitor the TCCR feed batch temperature and document the loop number in the TCCR Feed Batch Qualification Report and the ERD. Operating procedures will update the thermocouple loop number as required during implementation of the ERD for transition to "Qualified" operation. The Tank 11 impact evaluation will determine the minimum level in Tank 10 which ensures that the thermocouple will remain in the salt solution during batch processing. Operating procedures will be updated to include the endpoint level of the batch.

7. *Prior to transfer initiation to the TCCR Unit, ensure the TCCR feed batch supernate nitrite concentration in Tank 10 is greater than or equal to 0.0275 M.*

   The minimum nitrite concentration in waste tank supernate shall be maintained greater than or equal to 0.0275 M (this value accounts for analytical uncertainty) to effectively eliminate the corrosion, radiolysis of organics, and catalyst mechanism as flammability concerns, as discussed in Reference AA (Ref. 14). (Ref. 3, Sect. 5.8.2.57 Attribute g.)

   Engineering shall verify the minimum nitrite concentration of 0.0275 M for each TCCR feed batch by sampling or engineering evaluation. The TCCR Feed Batch Qualification Report shall document the minimum nitrite concentration, and ensure that the allowed liquid additions maintain the nitrite concentration at or above the limit.

8. *Prior to transfer initiation of initial liquid waste feed to the TCCR unit and every 300 days thereafter during operations, ensure the TCCR IX Column Water Jackets are filled to overflow with water.*

   This control is no longer required (on an individual IX Column) once at least two vent paths are established on the IX column. The 300-day periodic water jacket refill is based on Reference JJ (Ref. 6). (Ref. 3, Sect. 5.8.2.57 Attribute h.)

   Operating procedures confirm that the IX Column Water Jackets are filled to overflow. A maximum frequency of 240 days is used to protect the 300-day frequency and is tracked in the Safety Requirement Management System (SRMS). Verification that the water jackets were filled within the last 240 days is performed in Operating procedures. Additionally, second person verification that the Water Jacket drain valve is closed and

that liquid overflows the jacket during filling of the TCCR IX Column Water Jacket shall be verified in operating procedures.

9. *Prior to transfer initiation to the TCCR Unit, verify Tank 10 waste temperature is greater than or equal to the Tank 10 TCCR feed batch temperature limit. During transfers to the TCCR Unit, verify Tank 10 waste temperature is greater than or equal to the Tank 10 TCCR feed batch temperature limit every 7 days.*

   The Tank 10 TCCR feed batch temperature limit is documented in the ERD (Ref. 46) (Ref. 10)*, per item 6 of the TCCR Operations Program. The 7-day periodic check of waste temperature is based on expected operating conditions in Tank 10 and supported by historical Tank 10 temperature measurements (Ref. HH)* (Ref. 1)*. To ensure an accurate waste temperature indication, the elevation of the temperature element shall be within the supernate level in the waste tank.* (Ref. 3, Sect. 5.8.2.57 Attribute i.)

   Roundsheets shall verify that the Tank 10 supernate temperature is at or above the lower temperature limit prior to transfer initiation to the TCCR unit and twice weekly to ensure the 7-day frequency is met. Temperature measurements shall be performed locally at Tank 10 using the Altek Universal Thermocouple Calibrator Model 422 as the Measuring and Test Equipment (M&TE). Reference 11 also evaluated use of a Fluke 714B Temperature Calibrator but results in a higher uncertainty. Use of the Fluke 714B rather than the Altek Universal Model 422 requires Engineering review and approval. If the feed batch temperature is shown to be less than the limit, feed to the TCCR Unit shall be secured and the Shift Manager and Engineering notified.

10. *Combustible fueled (e.g., gasoline, diesel, propane) engines and fuel containers shall not be present within 20 feet of the TCCR Process Enclosure during operations of the TCCR Unit (i.e., feed being provided to TCCR Unit), excluding attended combustible fueled (e.g., gasoline, diesel, propane) engines and fuel containers totaling less than or equal to 6 gallons.* (Ref. 3, Sect. 5.8.2.57 Attribute j.)

    Operating procedures shall verify that the required exclusion zone standoff barriers are in place and that fuel containers are not present prior to initiating feed to the TCCR Unit and periodically thereafter via the roundsheets. [Note: Fuel containers equal to or less than 6 gallons are exempt from this requirement but should not be present in the exclusion zone in accordance with the Fire Protection Program (Ref. 11).]

11. *Vehicle barriers (e.g., jersey barriers) shall be established between areas of vehicle access and the TCCR Process Enclosure during operations of the TCCR Unit (i.e., feed being provided to the TCCR Unit).* (Ref. 3, Sect. 5.8.2.57 Attribute k.)

    Operating procedures shall verify that the vehicle barriers are in place prior to initiating feed to the TCCR Unit; second person verification shall be performed to verify the vehicle barriers are in place prior to transfer initiation to the TCCR unit.
    Periodic re-verification of the vehicle barriers shall be performed via the roundsheets.

12. *Liquid additions to Tank 10 shall be limited to less than or equal to 3,000 gals. (or dilution volume limit determined by engineering evaluation) for each TCCR feed batch. This control is applicable from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.*

    If an engineering evaluation is used to increase the dilution volume limit, the evaluation shall be based upon the methodology of Reference HH (Ref. 5) *using existing waste tank conditions (including consideration of previous liquid additions for the TCCR feed batch). If liquid additions to Tank 10 exceed the volume limit, the Batch Equilibrium Contact Test is invalidated.* (Ref. 3, Sect. 5.8.2.57 Attribute l.)

    Operating procedures and the Morning Report shall track liquid additions to ensure that the maximum allowed volume is not exceeded once the resin test vials have been deployed into Tank 10 until the batch is complete. This will be performed by tracking liquid additions during the Sample and Qualified phases.

    The 3,000 gallons limit is derived from a maximum dilution effect of 20% assuming a protected minimum liquid volume of 15,000 gallons in Tank 10 (Ref. 5). The maximum liquid addition volume of 3,000 gallons may be increased by engineering evaluation (see section 4.2.4). Pre-filter backflushes using Tank 10 salt solution do not count against this limit since it is returning the same compositional material back to Tank 10. Should other liquids be used to clean or backflush the pre-filters, these shall be counted as liquid additions and tracked against the limit.

    During liquid additions to Tank 10, second person verification shall be performed to confirm the volume added to the tank. This may be performed by one of the following methods:

    - Flow/amount indications on the associated system

- Pump maximum (run-out) flowrate on the associated system versus the amount of time the pump is operated
- Level change in the sending vessel
- Level change in Tank 10

Should the liquid additions volume for a feed batch be exceeded, operating procedures shall secure the Tank 10 Transfer Pump and the Shift Manager and Engineering notified.

Engineering shall specify the Tank 10 Transfer Pump suction elevation that will ensure a minimum salt solution volume of 15,000 gals. An engineering evaluation shall document the required minimum elevation.
The engineering evaluation may consider such things as salt sounding results before and after recirculation, expected volume of salt dissolved during recirculation, specific gravity measurements, sample results and level compensation for conservatism. Prior to transfer initiation to the TCCR Unit, operating procedures shall verify that the Tank 10 Transfer Pump suction elevation is set at a level to protect the minimum volume of 15,000 gals. The TCCR Feed Batch Qualification Report shall document successful placement of the Tank 10 Transfer Pump suction elevation.
Changes to the Tank 10 Transfer Pump suction elevation are permitted when in the Qualified phase provided that an engineering evaluation documents that the new elevation protects the minimum 15,000 gals. salt solution volume in Tank 10. Upon termination of feed to the TCCR Unit, if the shut-down is due to a planned transfer pump elevation change, then operating procedures shall direct installation of an Administrative Lock on the Tank 10 Transfer Pump. Once the Tank 10 Transfer Pump is repositioned, and the SW11.1-WTE Section 7.2 procedure updated, the Feed Batch Qualification Report will be revised. The revised Feed Batch Qualification Report and updated SW11.1-WTE Section 7.2 will drive a revision to the ERD. The Administrative Lock may then be removed upon completion of the Tank 10 Transfer Pump elevation change and the associated revision of the Feed Batch Qualification Report. Prior to initiating feed to the TCCR Unit, operating procedures shall verify that the Tank 10 Transfer Pump elevation, as documented in the SW11.1-WTE Section 7.2, is the same as the elevation stated in the revised ERD. Other attributes needed to protect the feed batch Qualified status shall remain in effect including the feed batch qualification temperature limit, liquid additions to Tank 10 and IX Column flushes to Tank 10.

13. *IX column flushes to Tank 10 shall be limited to two flushes, (or IX Column flush limit determined by engineering evaluation) for each TCCR feed batch. This control is applicable from the time the Batch Equilibrium Contact Test has been initiated (i.e., resin*

test vials deployed in the waste tank) until the TCCR feed batch processing has been completed.

If an engineering evaluation is used to increase the permitted IX column flushes, the evaluation shall be based upon the methodology of Reference HH (Ref. 5) *using existing waste tank conditions (including consideration of previous IX column flushes for the TCCR feed batch). If IX column flushes to Tank 10 exceed the limit, the Batch Equilibrium Contact Test is invalidated.*

Automatic venting of the IX columns does not count towards the two-column flush limitation, as this automatic cycling is a short duration (e.g., seconds) and has negligible impact on bulk chemistry. (Ref. 3, Sect. 5.8.2.57 Sect. m.)

The number of allowed IX Column flushes for each feed batch is determined by Engineering and documented in the TCCR Feed Batch Qualification Report and ERD. Implementation of the ERD for the associated TCCR feed batch updates operating procedures which track IX Column flushes against the feed batch limit.

Since the IX Column flushes to Tank 10 will be performed using liquids other than Tank 10 feed material, these additions shall also be counted as liquid additions to Tank 10.

Should the number of IX Column flushes for a feed batch be exceeded, operating procedures shall secure the TCCR transfer pump and the Shift Manager and Engineering notified.

14. *Prior to initiation of flow for multiple IX column series operation (i.e., lead/lag configuration), ensure the lead column is flushed with greater than or equal to 150 gallons of liquid (e.g., feed, flush water, caustic) to Tank 10 or Tank 11.*

    This requirement is not applicable to the process flow interruptions due to TCCR pre-filter back-flushes or placing a new, unloaded IX column in service in the lead position. (Ref. 3, Sect. 5.8.2.57 Attribute n.)

    Operating procedures shall ensure that prior to initiation of flow for multiple IX column series operation that the lead column(s) have been flushed with a minimum of 150 gallons to either Tank 10 or Tank 11. If flushed to Tank 10, then the flush shall be included in the flush count to Tank 10 and liquid addition volume if liquid other than feed is used. The minimum amount of 150 gallons is verified by proper valve alignment via camera inspection, confirmation of total volume by flow totalizer, and successful flush

completion by camera in the receipt tank. Second person verification via camera inspection of the following valve alignments shall be performed:

- TCCR IX Column Feed Inlet Valves for all "non-lead" TCCR IX Columns are closed
- TCCR IX Column Outlet Valves for all "non-lead" TCCR IX Columns are closed
- TCCR IX Column Bypass Valve for the "lead" TCCR IX Column is closed
- TCCR IX Column Vent Valve for the "lead" TCCR IX Column is closed

Additionally, during the TCCR IX Column flush, second person verification shall be performed to ensure the 150-gallon value for the flush requirement is satisfied. This may be performed by one of the following methods (depending on the flush media):

- Using TCCR Unit process flow indication amount (for feed or caustic) versus the amount of time necessary to achieve the 150-gallon value for the flush requirements (e.g., if flow were 5 gpm, 30-minute flush time would be required)
- Using the flush/well water flow totalizer indication amount (for flush/well water)
- Using level change in the sending vessel (for flush/well water) to ensure it is consistent with the flush volume

Additionally, after initiating the TCCR IX column flush, verify flow occurs into Tank 10 or Tank 11 (as applicable) via inspection camera.

Should more than two IX columns be placed in series operation, each IX column other than the final column in series shall be flushed with a minimum of 150 gallons.

15. *Prior to removal of an IX Column from the TCCR Process Enclosure, the IX Column liquid inventory shall be reduced (using pressurized air) until no liquid flow is observed exiting the transfer line to Tank 10.*

    The term "no liquid flow is observed exiting the transfer line" is intended to mean that the majority of the liquid has been removed from the IX column during the de-inventory process and is primarily verified by the liquid to air transition verification discussed in Section 5.5.4.2.53.4 (Ref. *2*). *Continuous flow of liquid should not be observed after this process; however, liquid dripping from the transfer line back to the tank is permitted.* (Ref. 3, Sect. 5.8.2.57 Attribute o.)

    Operating procedures shall verify that pressurized air is supplied to the appropriate IX column by valve alignment determined by camera inspection, and that liquid is received

in Tank 10 by inspection camera. Second person verification shall be performed to ensure the following valve alignments via inspection camera.

- TCCR IX Column Feed Inlet Valve (for IX Column being de-inventoried) is closed.
- TCCR IX Column Vent Valve (for IX Column being de-inventoried) is closed
- TCCR IX Column Process Outlet Valve is closed
- TCCR IX Column Inlet Air Valve (for IX Column being de-inventoried) is open
- TCCR IX Column Outlet Valve (for IX Column being de-inventoried) is open

Operating procedures shall also ensure second person verification is performed to ensure liquid flow cessation with evidence of "liquid to air" transition. Continuous flow of liquid should not be observed after the de-inventory process; however, liquid dripping from the transfer line back to the tank is permitted.

7.0 Deviations

Proposed deviations from the requirements as described by this PDD shall be evaluated as deemed appropriate. The proposed deviation shall be reviewed and approved by the Tank Farm Program Review Committee (PRC).

8.0 References

1. Fellinger, T.L., "Cs-137 Loading Penalty and Error Assessment for Crystalline Silicotitanate (CST) IONSIV R9120-B for the Tank Closure Cesium Removal (TCCR) System Demonstration Project", X-ESR-H-00945, Rev. 1, September 2018.
2. Tank Closure Cesium Removal (TCCR) and Interim Safer Storage (ISS) Change Request, HLW-CRF-17008, Rev. 1, October 2018.
3. "Concentration, Storage, and Transfer Facilities Technical Safety Requirements", S-TSR-G-00001. Rev. 56, July 2018.
4. Fairchild, P.A., Fellinger, T.L., "Radionuclide Concentrations of Streams for the Tank Closure Cesium Removal (TCCR) System", X-ESR-H-00860, Rev. 1, January 2018.
5. Fairchild, P.A., "Tank Closure Cesium Removal System Heat Transfer Analysis of Ion Exchange Column with Water-Filled Annulus", X-ESR-H-00924, Rev. 1, May 2018.
6. Caldwell, T.B., "Estimation of the Loss Rate from the Water Bath of the TCCR Column Assemblies from Evaporation and Radiolysis", X-CLC-H-01233, Rev. 1, August 2018.
7. Williams, Fred, "High Level Waste Emergency Response Data and Waste Tank Data", N-ESR-G-00001, Rev. various.
8. Bui, H., "CSTF Flammability Control Program", WSRC-TR-2003-00087, Rev. 32, March 2018
9. Martin, Keisha, "CST Corrosion Control Program", WSRC-TR-2002-00327, Rev. 9, December 2015.
10. Taylor-Pashow, Kathryn, "Task Technical Quality Assurance Plan for In-Tank Batch Contact Testing in Support of Tank Closure Cesium Removal", SRNL-RP-2018-00863, Rev. 0, September 2018.
11. Barwick, S.C., "Instrumentation Uncertainties Evaluation for Waste Tank Thermocouples", J-CLC-H-01099, Rev. 0, June 12, 2018.
12. Hooker, Azikiwe, "Tank Farm Transfer Control Program, Pump Tank Transfer Jet Control Program, and Waste Tank Chemical Cleaning Program", WSRC-TR-2002-00403, Rev. 26, June 2018.
13. Tank Farm Safety Analysis Input Deck, http://pceweb.srs.gov/input deck.
14. Guardiano, S. K., "Consolidated Hazard Analysis for Tank Closure Cesium Removal (TCCR) Demonstration", U-CHA-H-00010, Rev. 0, August 2018.

Appendix A. Expected TCCR Operational Sequence

ERD Revision setting Tank 10 to "BATCH PREP"

Requires Gas Release Mode Evaluation and engineering evaluation of impacts for bulk water addition to Tank 10.

Permits start of Recirculation for bulk salt dissolution, aligns 3-way valve to Tank 10 (IV and Administrative Control Lock) and energization of th Tank 10 Transfer Pump. Also resets ERD TCCR low temperature limit to NA in this ERD.

After reaching target Specific Gravity or the Specific Gravity stabilizes, stop Recirculation.

De-energize Tank 10 Transfer Pump and align 3-way valve to TCCR Unit (IV and Administrative Control Lock) prior to resin test vial deployment.

ERD Revision setting Tank 10 to "SAMPLE", ERD table implements water addition tracking, and IX Column flushes.

Requires engineering evaluation for maximum water addition of 3,000 gals., update of Morning Report.

Prepare Sample Request Form for resin test vial deployment and dip sample (e.g., corrosion control, nitrite concentration and TCCR Process data needs)

Obtain a dip sample and deploy resin test vials. Ship dip sample to SRNL for analysis.

After a minimum of 10 days, retrieve resin test vials and ship to SRNL. Record Tank 10 temperature during retrieval of resin test vials and report value to Engineering.

Data Integrity Review Team (DIRT) reviews and accepts sample results when available (PS&R Engineering).

Perform a salt sounding as input to setting the Tank 10 Transfer Pump. DIRT acceptance of salt level measurement is required. A turbidity reading may be requested by Engineering to determine if any suspended solids are above the salt level. This information is also used to set the pump to avoid excessive pluggage of the pre-filters.

SRNL provides a memo/technical report (reviewed in accordance with E7 procedure 2.60) with Cs-137 loading results and nitrite concentration to Engineering. Engineering prepares batch qualification report including Cs-137 loading limit check, nitrite check, temperature low limit value, water addition limit value and IX column flush limit value.

Prepare engineering evaluation and reposition the Tank 10 transfer pump to the elevation specified to protect the 15,000 gallons minimum salt solution requirement and to minimize solids entrainment to TCCR Unit. Update SW11.1-WTE-Sect. 7.2.

Verify that the Tank 11 impact evaluation to receive TCCR material is complete.

ERD Revision setting Tank 10 to "QUALIFIED". ERD table also includes the low temperature limit and thermocouple loop number for implementation into operating procedures. Update Morning Report for water additions (if required).

Verify that the Tank 10 Transfer Pump was repositioned to protect a minimum of 15,000 gals.

TCCR Operations Round Sheets initiated.

Operating procedures verify IVs and prerequisites required prior to initiation of transfers to TCCR Unit (Tank 10 Transfer Pump elevation reset, valve alignments, 20-foot barricades in place around Process Enclosure, flammable container placards in place, flammable containers not present within barricade, etc.). Tank 10 Transfer Pump may be energized to initiate feed to TCCR Unit.

Upon completion of salt batch processing, return to start with ERD revision to "BATCH PREP".

LW FORM

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Document Number: U-TRT-G-00012 Revision: 1

Document Title: CSTF Tank Closure Cesium Removal Operations Program Description Document

The following checklist is required to be completed and attached to the document under review in compliance with Manual E7 and S4 procedures. This list should not be considered all inclusive. Add any additional notes or comments to the end of the checklist.

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	VERSION / FORMAT		
1	If revising an existing document, are you starting with the latest, approved version of the document obtained from SmartPlant Foundation (SPF) or DCR?	Yes	
2	Are all OSR or SPF forms properly and completely filled out and is the current approved version of the form used?	Yes	
3	Does the document format include all of the sections as described in manual E7 and S4 procedures (2.31A ,3.60, etc.)?	Yes	
4	Are all of the pages properly labeled with Document Number, Revision Number, and Sequential Page/Sheet Number?	Yes	
5	Are the Subject and Purpose clearly stated and do they meet the end-users needs?	Yes	
	REFERENCES		
6	Are all References properly documented within the document and can they be easily verified within Document Control, on-line, or within the library, etc.? If reference documents are not readily available, are they attached?	Yes	
7	Have the correct design bases documents been identified (e.g., Codes, Standards, DOE Orders, SRR Requirements, Regulatory Requirements, DSA)?	Yes	
	OPEN ITEMS / INPUT		
8	If data is transferred from other documents, calculations or sources, is this data correct and applicable?	Yes	
9	Are all inputs found in the body of the document or calculation individually listed and if the document is a calculation, numbered in the Inputs section?	Yes	Not a calculation
10	Is there a reference/source for each input?	Yes	
11	Do the identified references/sources fully support the inputs and does the data meet appropriate quality assurance requirements?	Yes	
12	Have the correct operational and functional requirements of the facility been properly considered?	Yes	

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	OPEN ITEMS / INPUT – continued		
13	Have appropriate operational modes and worse case scenarios been considered?	N/A	
14	Are all assumptions used to support the document individually listed and numbered in the Assumptions section?	N/A	Assumptions are listed for future engineering evaluations, but do not support the document.
15	Is there a justification written for each assumption that includes a technical basis?	N/A	
16	Do the justifications adequately support the assumptions?	N/A	
17	If the document is a calculation and there are Open Items, has the calculation been statused as preliminary? Note: A Confirmed calculation cannot have Open Items.	N/A	
18	If the document is a preliminary calculation, have actions required to change the status from "preliminary" to "confirmed" been listed as "open items"?	N/A	
19	If the document has open items, is there a method identified to track them? List tracking numbers in Comments (STAR, POD item number, etc.).	N/A	No Open Items
	ANALYTICAL METHODS AND COMPUTATIONS		
20	Are the analytical methods and computations clearly spelled out step-by-step?	N/A	Computations/Analysis is not performed.
21	Is the analytical approach in use clearly described with justification along with alternative methods?	N/A	
22	Is the methodology consistent with the purpose and objective?	N/A	
23	Are mathematical derivations correct, including dimensional consistency of results?	N/A	No results are provided.
24	Have calculations been checked for errors as applicable per E7-2.31A, Sections 5.3.2.5 and 5.5.1? Where a calculation has multiple iterations of the same computation with numerous input and output values, the Verifier/Checker may select a representative sample of the total input and output values for review.	Yes	Values provided herein are in accordance with the cited reference.
25	Were the analysis inputs correctly incorporated into the analysis and are the outputs reasonable compared to the inputs?	N/A	No analysis is provided.
26	Is the Summary of Conclusion clearly stated? Does it meet the end-user's needs? Clearly state if results meet/do not meet the Objectives of the analysis?	Yes	
27	Are the numeric values consistent with the appropriate accuracy (significant figures) of the analysis?	N/A	No analysis is performed.
28	Are safety margins consistent with good engineering practice?	Yes	

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	SOFTWARE		
29	Is software (including spreadsheets) used? If NO, then "N/A" this section.	N/A	Microsoft Word 16.0.10730.20264 32-Bit
30	Have computer software programs used for calculations been evaluated and properly classified for this activity using OSR form 19-337 (SWCD), per 1Q QAP 20-1 and E7-2.25? Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38. B) The SWCD (software classification document) form is a site-wide application in Lotus Notes.	N/A	
31	Is computer software used for the analysis being controlled per E7-2.31A, Section 5?	No	Generally Commercially Available Software
32	Were appropriate analysis methods and computer methods used?	Yes	
33	If a computer program or model is used in the calculation, is it used within the range of validity, or is use outside the range of established validity justified?	N/A	
34	Was the software program used within any restriction, criteria or test frequency requirements in the Software Quality Assurance Plan? (SQAP) (e.g., computer operating system/platform criteria, software within testing frequency).	N/A	
35	Is the software used noted on the Calculation cover sheet and referenced appropriately in the calculation?	N/A	
36	If the calculation supports the DSA, is the software and version used on the SSIL (Safety Software Inventory List) when required? Provide explanation in Comments. Notes: A) Engineering Calculations meeting the validation requirements of E7-2.31A, where a documented, approved process provides for verification of the results for each use are Exempt – see Row 38 B) The SSIL is updated on an annual basis so recently approved SQAPs may not be added to the SSIL until the next annual update.	N/A	Generally Commercially Available Software
37	Are the equations shown in the calculation, including example functions where Excel spreadsheets or MathCad is used?	N/A	
38	If using general-purpose commercially available software as described in E7-2.31A, Section 5.5.1, then answer YES and describe checking method (5.5.1.2.C 1, 2, or 3) in Comments	Yes	Values provided were compared to the cited reference and agree. No calculations were performed.
39	Have computer program error reports been checked for potential effect on the analysis?	N/A	

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
	RESULTS / CONCLUSIONS		
40	Are the results of the document consistent with the input and assumptions?	N/A	Calculations are not performed
41	Do the results of the document affect any other technical documents?	Yes	
42	Do the results substantiate the conclusion?	Yes	
	APPROVALS		
43	Does the document identify the method of verification, if applicable, and does it have a signature block for the verifier/checker?	Yes	

Checker: P.A. Fairchild (Print) / PA Fairchild (Signature) Date: 7/04/2019

Item No. Cont.	Comment Continuation

LW FORM

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Items 44-56 are only to be completed when Verification by Document Review is being performed. The verifier assures the technical accuracy of the document by performing administrative and mathematical checks as appropriate, and by evaluating the document against the following questions:

Item No.	Item	Yes / No N/A	Comments (use continuation page at end of form if more space is needed)
44	Were the inputs correctly selected and identified?	Yes	
45	Are the assumptions made in the performance of the design or analytical activity adequately described and reasonable?	N/A	
46	When necessary, are the assumptions identified for subsequent re-verification when the detailed design activities are completed?	Yes	
47	Were appropriate design or analytical methods and computer programs used?	Yes	
48	Were the design or analytical inputs correctly incorporated into the design, analysis or evaluation?	Yes	
49	Have engineering actions required to support risk handling strategies been verified?	Yes	
50	Is the design output reasonable compared to the design or analytical inputs?	Yes	
51	Are the necessary design inputs for interfacing organizations specified in the design documents or in supporting procedures or instructions?	Yes	
52	Have suitable materials, parts, processes, and inspection and testing criteria been specified?	Yes	
53	Have existing and potential workplace hazards been identified, evaluated, and controls incorporated for the risk to worker injury or illness?	Yes	
54	Was a review conducted to confirm that there are no interferences with other ongoing or planned modifications?	Yes	
55	Have engineering judgments been identified, technically justified, and supported?	Yes	
56	Have design optimization strategies been considered / met (e.g., appropriate tailoring of requirements, design attributes, and operating strategies)?	Yes	

Verifier: P.A. Fairchild (Print) / PA Fairchild (Signature) Date: 02/04/2019

LW FORM

ENGINEERING CHECKING AND VERIFICATION BY DOCUMENT REVIEW CHECKLIST

Procedure Ref. E7-2.31A and S4-ENG.51

Item No. Cont.	Comment Continuation