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Evaluation of 241-AZ Tank Farm Supporting Phase 1 Privatization Waste Feed Delivery

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Abstract: This evaluation is one in a series of evaluations determining the process needs and assessing the adequacy of existing and planned equipment in meeting those needs at various double-shell tank farms in support of Phase 1 privatization. A number of tank-to-tank transfers and waste preparation activities are needed to process and feed waste to the private contractor in support of Phase 1 privatization. The scope of this evaluation is limited to process needs associated with 241-AZ tank farm during the Phase 1 privatization.

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EVALUATION OF 241-AZ TANK FARM, SUPPORTING PHASE 1 WASTE FEED DELIVERY

November 1998

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EXECUTIVE SUMMARY

The mission of the Tank Waste Remediation System (TWRS) Project is to provide safe storage and management of past and future tank waste; retrieval, treatment, and disposal of the waste; decontamination and disposal of TWRS facilities; and final closure of the tanks. To reduce the potential for additional contamination to the environment, the U.S. Department of Energy (DOE) plans to transfer the tank waste to privately owned and operated waste immobilization facilities. This approach is referred to as TWRS privatization. DOE intends to conduct the waste retrieval and immobilization mission using a phased approach. During Phase 1 privatization, the sources of wastes fed to the immobilization facilities will largely be from double-shell tanks (DSTs). Waste from both of the tanks in the 241-AZ Tank Farm are planned to be delivered to the private contractor as high-level waste (HLW) feed during Phase 1 privatization. Both tanks 241-AZ-101 and 241-AZ-102 contain aging waste. The solids will be suspended in the liquid contained in the two AZ tank farm tanks to create a slurry. The slurry will be transferred in several batches to the private contractor facility. The private contractor will separate the slurry into HLW and low-activity waste (LAW) fractions. The HLW fraction will be immobilized. The LAW fraction will be returned to the tank farms for staging. Once the two AZ tank farm tanks have been emptied of the waste currently stored, the tanks are scheduled to become staging tanks for other HLW from 241-AY tank farm and for waste retrieved from waste stored in the 241-C tank farm tanks 241-C-106, -104, and potentially -102. During Phase 1 privatization, in addition to delivering feed to the private contractor, other tank-to-tank waste transfers will also occur in support of 242-A Evaporator operation, saltwell pumping from single-shell tanks (SSTs), and other ongoing TWRS operations.

This evaluation is one in a series of evaluations determining the process needs and assessing the adequacy of existing and planned equipment in meeting those process needs at various DST farms in support of Phase 1 privatization. The purpose of this evaluation is twofold: establish the process needs associated with waste processing and tank-to-tank transfers to support feed delivery to the private contractor during Phase 1 privatization; and

evaluate the identified process needs against existing and planned structures, systems, and components (SSCs) for 241-AZ tank farm to determine whether existing and planned SSCs are capable of supporting the Phase 1 privatization mission. The scope of this evaluation is limited to process needs associated with 241-AZ tank farm during the Phase 1 privatization. The scope is consistent with the alternative case identified in DeLozier (1998). The SSCs examined are associated with waste preparation and transfer, utilities, instrumentation and control, and ventilation. Where information is not available to establish a quantitative process need or adequately assess whether existing and planned SSCs are capable of supporting the privatization mission, an issue is identified and a recommended approach to arrive at the necessary information is provided.

An issues list is developed where deficiencies in the system are identified. Where issues are identified, recommended actions are proposed. Issues have been categorized according to the system to which they apply, namely, waste preparation and transfer; utilities; instrumentation, monitoring, and control; and ventilation. The following list highlights some of the key issues and recommended actions that have been identified by this assessment:

Waste Preparation and Control Issues

***Issue** -A dilution/flush system in AN farm is identified as part of the scope of Project W-211. The AN dilution/flush system will service 241-AZ-102, but it is not clear that piping for the diluent or flush to 241-AZ-101 is included.*
***Recommendation** -Piping from AN dissolution/flush system to 241-AZ-101 needs to be included as work scope.*

***Issue** - It is not clear that mixer pumps installed in 241-AZ-101 can be started after a period of inactivity in the tank and provide the necessary level of solids mobilization. A full scale mixer pump test, which demonstrated the ability of mixer pumps to start after long periods of inactivity in a solids layer, has not been performed in a tank with*

Hanford Site or similar waste.

Recommendation *- Testing of the 241-AZ-101 mixer pumps shall help to establish whether the mixer pumps can run after a period of inactivity and help in determining the effectiveness of the mixer pumps.*

Issue *- Two large mixer pumps and a transfer pump will be required in each tank. The interference between the mixer pump discharge stream and the transfer pump is not adequately developed. The transfer pump may need to be operated during mixer pump operation to support slurry transfers.*

Recommendation *- Model the settling of solids in the 241-AZ-101 tanks to determine whether it is necessary to provide slurry transfer pumps that can be operated during mixer pump operation and withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST or specify a transfer pump that can operate and withstand forces imparted by full speed mixer pump operation.*

Issue *- The current configuration of 241-AZ-101 and -102 requires a minimum heel of 1.63 m (64 in.) above the tank bottom. The annulus pump pits in each tank drain into the tanks at a level of 1.63 m (64 in.) above the tank bottom. If the level in the tanks is drained to below 1.63 m (64 in.), a pathway would exist for contaminated vapors to be drawn from the primary tank into the annulus.*

Recommendation *- Perform an evaluation to determine the best course of action to allow the tanks to be drained past the 1.63 m (64 in.) level. Options to be considered to solve this issue include plugging the annulus pump pit drains or interlocking the primary and annulus ventilation systems to shutdown annulus ventilation if the primary ventilation system is not operating. OSD-T-151-00017 would need to be revised to reflect the change.*

<u>*Utilities Issues*</u>

Issue *- The existing tank farms electrical supply may not be adequate to supply the process need maximum electrical load (simultaneous operation of eight 224-kW mixer pumps and four 44-kW transfer pumps).*
Recommendation *- Perform an evaluation to determine the feasibility of either transferring some tank farms loads to other electrical supply lines in the area or refine the schedule constraints associated with simultaneous mixer pump operation to limit total electrical load.*

<u>*Instrumentation, Monitoring, and Control Issues*</u>

Issue *- Existing temperature monitoring system may not be adequate to monitor for waste solids suspension during mixer pump operation.*
Recommendation *- Complete the mixer pump test in tank 241-AZ-101. Data gathered from this test will support a decision whether existing temperature monitoring is adequate.*

<u>*Ventilation Issues*</u>

Issue *- Thermal analysis of heat removal and ventilation system performance for waste feed delivery activities (e.g., degassing and solids dissolution) for the 241-AZ Tank Farm are preliminary in nature.*
Recommendation *- Perform additional refined thermal analysis for the retrieval functions to be performed in the 241-AZ Tank Farm.*

Issue *-The existing primary ventilation exhaust fan does not provide the specified level of vacuum and airflow as installed. Too much air in leakage is occurring into the Aging Waste Facility (AWF) tanks to allow control of the ventilation flows through each tank.*

***Recommendation** - For the AWF to meet the design and performance requirements for Project W-030, the fan and drive apparatus will require design modifications. These modifications are currently being reviewed by TWRS operations. Alternatively, the possibility of eliminating air in leakage sources could be evaluated.*

***Issue** - Equipment (thermocouple tree, transfer pumps, and mixing pumps) will require installation or removal from the DST, which will create openings in the DST dome to atmosphere during this operation. To insure the containment of the DST vapors, a negative pressure in the tank dome needs to be maintained. The ventilation system may not have enough capacity to insure that the tank dome can be maintained at a negative pressure while inserting equipment and perform all its other functions for the other three tanks in the system.*

***Recommendation** -Verification needs to be performed to assure that the ventilation system will be capable of maintaining a negative pressure in the tank dome during equipment change out. Portable exhausters could be used if it is determined that the current ventilation system is inadequate for equipment changeout.*

***Issue** - The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational and leak detection for the primary tank is provided by conductivity probes in the tank annulus.*

***Recommendation** - It is not known at this time if the mixer pump operation will require a functional annulus exhaust system for heat removal or if the system will be functional. Additional, refined thermal analysis for the retrieval functions to be performed in the 241-AZ tank farm need to be completed to confirm the preliminary calculations presented here.*

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LIST OF TERMS

AB	Authorization bases
ALARA	As low as reasonably achievable
AWF	Aging Waste Facility
BIO	Basis for Interim Operation
CAM	Continuous air monitor
DOE	U.S. Department of Energy
DST	Double-shell tank
GRE	Gas release event
HEGA	High-efficiency gas adsorber
HEME	High-efficiency mist eliminator
HEPA	High-efficiency particulate air
HLW	High-level waste
LAW	Low-activity waste
LCO	Limiting condition for operation
LFL	Lower flammable limit
M&I	Management and Integration
MIT	Multi-Function Instrument Tree
NPSH	Net positive suction head
NPSHa	Net positive suction head (available)
PLC	Programmable Logic Controller
PUREX	Plutonium-uranium extraction
RL	U.S. Department of Energy Richland Operations Office
RTP	Readiness to proceed
SS	Safety significant
SSC	Structures, systems, and components
TMACS	Tank Monitoring and Control System
TSR	Technical safety requirement
TWRS	Tank Waste Remediation System
TWRSO&UP	Tank Waste Remediation System Operation and Utilization Plan
URSILLA	Ultrasonic Interface Level Analyzer
VFD	Variable frequency drive

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EVALUATION OF 241-AZ TANK FARM, SUPPORTING PHASE 1 WASTE FEED DELIVERY

1.0 INTRODUCTION

This evaluation is one in a series of evaluations determining the process needs and assessing the adequacy of existing and planned equipment in meeting those needs at various double-shell tank (DST) farms in support of Phase 1 privatization. A number of tank-to-tank transfers and waste preparation activities are needed to process and feed waste to the private contractor in support of Phase 1 privatization. Other tank-to-tank waste transfers also occur during the Phase 1 privatization time frame in support of 242-A Evaporator operation, saltwell pumping from single-shell tanks (SSTs), and other ongoing Tank Waste Remediation System (TWRS) operations.

1.1 PURPOSE OF EVALUATION

The purpose of this evaluation is to establish the process needs associated with waste processing and tank-to-tank transfers to support feed delivery to the private contractor in support of Phase 1 privatization. Additionally, the process needs are evaluated against existing and planned structures, systems, and components (SSCs) for 241-AZ tank farm to determine whether existing and planned SSCs are capable of supporting the privatization mission.

1.2 SCOPE OF EVALUATION

The scope of this evaluation is limited to process needs associated with 241-AZ tank farm during the Phase 1 privatization. The scope is consistent with the alternative case identified in DeLozier (1998). The time frame examined is through 2016. The SSCs examined are associated with waste preparation and transfer, utilities, instrumentation and control, ventilation and sampling. Where information is not available to establish a quantitative process need an issue is identified stating how to arrive at the necessary information.

1.3 BACKGROUND INFORMATION

The mission of the TWRS Project is to provide safe storage and management of past and future tank waste, retrieval, treatment, and disposal of the waste, decontamination and disposal of TWRS facilities, and final closure of the tanks. To reduce the potential for additional contamination to the environment, the U.S. Department of Energy (DOE) plans to transfer the tank waste to privately owned and operated waste immobilization facilities. This approach is referred to as TWRS privatization. Immobilized low-activity waste (LAW) will be returned to DOE and disposed onsite in engineered facilities. Immobilized high-level waste (HLW) will be returned to DOE and stored until a repository is available for final disposal. Waste removal from the DST system also creates room for waste removed from SST systems. DOE intends to conduct the waste retrieval and immobilization mission using a phased approach. In Phase 1, the sources of wastes fed to the immobilization facilities will largely be from DSTs. Most SST waste will be treated during a Phase 2, a follow-on phase to the Phase 1 effort.

In January 1998, the Hanford Site management and integration (M&I) contractor team submitted to U.S. Department of Energy, Richland Operations Office (RL) analyses demonstrating readiness to proceed (RTP) with Phase 1B, TWRS privatization (Umek 1998). Subsequent to demonstrating readiness to proceed with Phase 1B, TWRS privatization, the Hanford Site M&I contractor team was requested by DOE (Taylor 1998) to evaluate a second alternative within privatization to the baseline. The key features associated with this second alternative are discussed in DeLozier (1998). Although formal direction from RL has not been given to proceed with the features associated with this second alternative, this second alternative forms the basis for the evaluation of 241-AZ tank farm.

1.4 DOCUMENT ORGANIZATION

The main body of this document contains a summary of the conclusions and issues and recommendations associated with this evaluation, process description, process needs related to processing and transfers occurring during the Phase 1 privatization period, and summaries of the assessments completed for the waste preparation and transfer systems, utilities distribution system, instrumentation and control system, ventilation system and sampling system. Appendices contain detailed information related to the assessments completed for the waste preparation and transfer systems (Appendix A), utilities distribution system (Appendix B), instrumentation and control system (Appendix C), ventilation system (Appendix D) and sampling system (Appendix E). Appendix F contains calculations and analyses that have been prepared to support the bases for various process needs as well as the system assessments performed as part of this evaluation.

2.0 CONCLUSIONS, ISSUES AND RECOMMENDATIONS

Below is a summary compilation of issues identified through this assessment requiring resolution to support waste feed delivery for the Phase 1 privatization mission. Recommendations consist of either change to existing project scope if planned equipment is inadequate, establishment of new project scope where specific equipment deficiencies are identified, or further process development work where unknowns exist. This section is divided into subsections which correspond to the major systems reviewed in this assessment: waste preparation and transfer; utility distribution; instrumentation, monitoring, and control; ventilation; sampling.

2.1 WASTE PREPARATION AND TRANSFER SYSTEMS

The alternative case identified in DeLozier (1998) was the starting point for the evaluation of transfers in 241-AZ. All of the transfers originating or ending in 241-AZ were extracted from the transfer list, and paths were defined for each of the different tank to tank transfers. The transfer equipment in the different transfer paths was considered. It is important to note that equipment in the transfer route included existing equipment, planned equipment (where project scope is definite and definitive design is proceeding), and conceptual equipment (where project scope is indefinite and definitive design has not yet been started). Table 2-1 lists issues identified with the 241-AZ waste preparation and transfer system and suggested work scope to address each issue.

Table 2-1. Waste Preparation and Transfer System Issues and Recommendations.

Issue	Process need	Basis for issue	Suggested scope of work to address issue
1. A dilution/flush system in AN farm is identified as part of the scope of Project W-211. The AN dilution/flush system will service 241-AZ-102 but it is not clear that piping the diluent or flush to 241-AZ-101 is included.	9.P4.1. Provide a diluent system to flush the transfer lines with inhibited water at 530 L/min (140 gal/min). 9.P4.2. The flush direction should be from the applicable 241-AZ pump pit to the Privatization Contractor facility. 9.P4.3. Flush transfer lines with water volumes equivalent to 1.5 times the transfer line internal volume.	Dilution/flush capability is needed in tank 241-AN-101 and the capability is not included in current project scope.	Piping from AN dissolution/flush system to 241-AZ-101 needs to be included as work scope.
2. It is not clear that mixer pumps installed in tanks can be started either initially or after a period of inactivity in a tank with several feet of solids above the pump intake, nor that the mixers will be capable of interim operation for the entire six plus years necessary to support waste feed delivery.	5.P1.1. Mixer pump operation should mobilize >90% of the solids initially in 241-AZ-101, >60% of the solids initially in 241-AZ-102, and >99% of the solids transferred to these tanks from 241-AY-102.	A full scale mixer pump test which demonstrated the ability of mixer pumps to start after long periods of inactivity in a solids layer has not been performed in a tank with Hanford Site or similar waste.	Modeling of mixer pump operation, and the testing of the 241-AZ-101 mixer pumps.
3. Two large mixer pumps and a transfer pump are planned in each of the 241-AZ tanks. The mixer pump discharge stream has not been adequately shown not to cause damage to the transfer pumps. It may be necessary to operate the mixer and trnasfer pumps simultaneously.	9.P3.6. Provide slurry transfer pumps which can be operated during mixer pump operation and withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST.	Although not well documented, anecdotal information indicates that line shaft driven vertical turbine pumps have experianced early failure when used in agitated tanks. It has been hypothesized that the early failure is due to the bending of the shaft caused by the forces of the agitation.	Modeling and scale testing of the transfer system is planned for this fiscal year. Results of the modeling and tests should be evaluated and mixer and or transfer pump designs changed as necessary to ensure compatibility.
4. The current configuration of 241-AZ-101and 2241-AZ-102 requires a minimum heel of 1.63 m (64 in.)	9.P2.?. Provide the capability of removing waste from the tank to within 0.25 m (10 in.) of the tank bottom.	The annulus pump pits in each tank drain into the tanks at a level of 1.63 m (64 in.) above the tank bottom. If the level in the tanks are drained to below 1.63 m (64 in.) the annulus ventilation system may draw contaminated vapor into the annulus pump pit.	Perform an evaluation to determine the best course of action to allow the tanks to be drained past the 1.63 m (64 in.) level. Options include plugging the drain or interlocking the ventilation system.

2.2 *UTILITY DISTRIBUTION SYSTEMS*

The existing tank farms electrical supply may not be adequate to supply either the process need maximum load or the postulated maximum schedule based electrical load. The process need load is more conservative than the postulated schedule load. The process need requires the independent operation of retrieval equipment in each of the four 200 East Area DST farms. This is equivalent to running two mixer pumps and one transfer pump in each farm, or, eight 224-kW (300-hp) mixer pumps and four 44-kW (60-hp) transfer pumps. The postulated schedule load is based on the integrated schedules. The integrated schedules show that at least once in each of the first three years of processing up to nine mixer pumps and one transfer pump may be needed simultaneously to suspend and transfer solids.

The simultaneous operation of nine mixer pumps (one set of mixers in each of 241-AY-102 (four 112 kW [150 hp]), AZ Farm (two 224 kW [300 hp]) and AN (or AW) Farm (two 224 kW [300 hp]) and one (224 kW [300 hp]) mixer in AP Farm) cannot be achieved. Load flow and voltage drop analysis of 13.8 kV line C8-L6, which serves the tank farms in 200 East Area, indicates that the line cannot provide power to the postulated schedule maximum TWRS load of nine mixer pumps and one transfer pump operating simultaneously without experiencing excessive voltage drop in the tank farm area. The voltage drop will also be excessive for the process need requirement since it is more conservative than the postulated schedule load. To resolve this potential issue the possibility of transferring some tank farm loads to other electrical supply lines in the area (lines C8-L5 and C8-L8 are the most likely candidates) could be explored. Or, a more detailed examination of schedule constraints for simultaneous operation of nine mixer pumps could be examined and the process need for independent operation of each farm can be modified.

2.3 INSTRUMENTATION, MONITORING AND CONTROL SYSTEM

Issues specific to instrumentation, monitoring and control are summarized in Table 2-2. These issues were developed only for existing equipment and planned equipment where project scope is definite and definitive design is proceeding. Additional issues may arise as project designs mature.

Table 2-2. 241-AZ Instrumentation, Monitoring and Control System Issues. (3 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
1. Existing 702-AZ (Project W-030) ventilation system provides primary ventilation to the four aging waste tanks (241-AZ-101, 241-AZ-102, 241-AY-101, and 241-AY-102). This ventilation system is permitted for a maximum total flow of 28.3 m^3/min (1000 scfm). If mixer pump or transfer pump operation requires a total ventilation flow beyond 28.3 m^3/min (1000 scfm) for acceptable operating conditions, some changes to the systems- such as verification of isokinetic nozzles and recalibration of flow monitoring loop are required.	5.P1.1 Mixer pump operation should mobilize >90% of the solids initially in 241-AZ-101, >60% of the solids initially in 241-AZ-102, and >99% of the solids transferred to these tanks from 241-AY-102. (note: mobilization of solids occurs through mixer pump operation)	Ventilation requirements for maintaining waste temperatures below limits during mixer pump operation are not currently defined. There is a potential that primary ventilation flows may require greater than 28.3 m^3/min (1000 scfm) to maintain waste temperatures during feed delivery activities.	Refined thermal analysis for the retrieval functions to be performed in the 241-AZ tank farm need to be completed to confirm whether the existing primary ventilation system is adequate. Note that increased flows will require regulatory approval. Additionally, the isokinetic system is controlled by an instrument which currently can be programmed only by the vendor. Also, losses with the system at higher flows may be significant enough to force a redesign of the sample transport lines.
2. The existing temperature trend recorder system is not calibrated for needed temperature gradient data as well as rate of change annunciation	2.S3.2 Temperature changeover time for solutions in tanks shall be ≤5.5°C/hr (≤10 °F/hr) (<52°C [125 °F]) or ≤11°C/day (≤20 °F /day) (≥52°C [125 °F]) AND 2.S3.3 Temperature gradients of solution in tanks shall be ≤100°C/m (55 °F/ft) within the solution and at the solution/vapor interface	Temperature gradient data as well as rate of change annunciation are required to meet the process need.	Issue work package to recalibrate the existing temperature trend recorder system for temperature gradient data record as well as rate of change annunciation

Table 2-2. 241-AZ Instrumentation, Monitoring and Control System Issues. (3 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
3. Existing temperature monitoring system may not be adequate to monitor for waste homogeneity during mixer pump operation.	5.P2.2 Mix tank contents to provide <TBD% variability of suspended HLW solids concentrations over the full depth prior to sampling and prior to beginning each feed transfer.	One method for evaluating success of waste mobilization and homogenization is to monitor the temperature gradient over the entire length of liquid column during waste mixing. RTDs or thermocouples are required at several elevations to give temperature gradients at various tank levels (primary tank). At present, there are Type J thermocouples (set of three thermocouples spaced at 0.10 m, 0.36 m, and 3.56 m [4 in.,14 in., and 140 in.] from bottom) installed in risers 13B, 13C, 13D, and 13A. Another set of three thermocouples are located 4 in. from bottom in risers 16A, B, and C. It is likely that this will not provide temperature gradient information required during transfer. The use of other instruments can also be used to determine the success of waste mobilization and homogenization such as the use of the suspended solids profiler.	Complete the mixer pump test in tank 241-AZ-101. Data gathered from this test will support a decision whether existing temperature monitoring is adequate. In addition, the use of other instruments, such as the suspended solids profiler should also be considered for use.

Table 2-2. 241-AZ Instrumentation, Monitoring and Control System Issues. (3 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
4. Current ENRAF™ systems in 241-AZ-101 and 241-AZ-102 use analog data signal. Improved accuracy can be obtained using a digital data signal.	9.P2.1 Determine total HLW solids mass (expressed as non-volatile oxides) transferred to the Privatization Vendor to within a variability of TBD%.	Tanks 241-AZ and 241-AZ-102 will be used as the staging tanks for transfer of HLW feed to the privatization contractor. Waste volume measurements of HLW batches transferred from these tanks to the privatization contractor will form part of the basis of payment. As such accuracy in this measurement will be very important.	Install ENRAF™ CIU to transmit digital signal.

2.4 VENTILATION SYSTEM

The 241-AZ ventilation system consists of a primary ventilation system and an annulus ventilation system for each tank within the tank farm. The primary ventilation system must remove heat, air, evaporated water and evolved gases from the primary tank during Phase 1 privatization waste feed delivery activities. The annulus ventilation system currently is not operable.

Table 2-3 lists issues identified with the 241-AZ ventilation system and its ability to support Phase 1 privation waste feed delivery. Suggested work scope to address each issue is also presented within the table.

Table 2-3. Ventilation System Issues and Recommendations. (4 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
Primary Ventilation Exhaust Fan - The existing primary ventilation exhaust fan does not provide the specified level of vacuum and airflow as installed. Too much air in leakage is occurring into the Aging Waste Facility tanks to allow control of the ventilation flows through each tank.	1.S10.2. Waste temperature shall not exceed 121°C (250 °F). 5.S1.1. Tank waste temperature shall be either: ≤90.6°C (≤195°F) in all levels of the waste; or ≤90.6°C (≤195°F) in the top 4.6 m (15 ft) of the waste and ≤102°C (≤215°F) in the waste below 4.6 m (15 ft). 5.S1.2. Temperature changeover time for solutions in tanks shall be ≤5.5°C/hr (10 °F/hr) (<52°C [125 °F]) or ≤11°C/day (20 °F /day) (≥52°C [125 °F]) 5.S1.3. Temperature gradients of solution in tanks shall be ≤100°C/m (55 °F/ft) within the solution and at the solution/vapor interface	The ventilation system must be adequately sized to accommodate the tank mixing operations during Phase 1 privatization feed delivery by removing heat, particulate, and water while maintaining vacuum within the tank headspace	For the Aging Waste Facility (AWF) to meet the design and performance requirements for Project 702-AZ (W-030) the fan and drive apparatus will require design modifications. These modifications are currently being reviewed by TWRS operations. The primary ventilation system fans performance need to be upgraded to meet the Procurement Specification W-030-P3 fan design condition of 28 m^3/min (1000 cfm) at 956 Pa (32 in. H_2O) with operation in a stable portion of the fan pressure curve (negative sloped portion of the pressure curve).

Table 2-3. Ventilation System Issues and Recommendations. (4 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
Primary Ventilation System Filter Train - 1. During operation of the 702-AZ (Project W-030) upgraded system there have been two instances where the filter plenum housings have had moisture collection problems. 2. The primary ventilation system HEPA and HEGA filter plenums are not in compliance with ANSI N509, Section 5.6.2. "The drain system shall be designed so that no unacceptable backup of liquids into the housing will occur" and "Each housing compartment shall have floor drains which meet all allowable air leakage criteria.".	1.S8.1. An active primary tank ventilation system for DSTs and AWF tanks shall be operable.	1. There is only a single HEME and condenser in the primary ventilation system. There is no way to replace either without bypassing them potentially loading moisture on the downstream filters. 2. Code requirements	1. Assess adding an additional HEME in the primary ventilation system. 2. Both filter housings should have drain capability added for all compartments
Ventilation Flow During Equipment Installation and Removal from Aging Waste Facility Tanks	Not a process need but an installation need.	Equipment (thermocouple tree, transfer pumps and mixing pumps) will require installation or removal from the DST which will create openings in the DST dome to atmosphere during this operation. To insure the containment of the DST vapors, a negative pressure in the tank dome needs to be maintained. The largest riser in the DST dome is 1.07 m (42 in.) in diameter which has an area of 0.89 m^2 (9.6 ft^2) open to the atmosphere. The existing ventilation system may not have enough capacity to insure that the tank dome can be maintained at a negative pressure and perform all its other functions for the other three tanks in the system.	The recirculation module for each AWF tank has two 0.20-m (8-in.) connections and required valving options to install a portable exhauster to increase the ventilation flow in conjunction with the existing ventilation system capacity and a negative pressure is expected to be maintained in the primary tank dome. Verification needs to be performed or existing documentation substantiated to assure how the ventilation system will be configured to maintain a negative pressure in the tank dome during equipment change out.

Table 2-3. Ventilation System Issues and Recommendations. (4 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
Radiation Levels in Recirculation Modules	Not process need but operational/ALARA concern.	An evaluation was performed (Kriskovich 1998 Draft) stating higher radiation in the re-circulation module was occurring due to aerosol/moisture settling out in piping, ductwork and equipment.	The report concluded in order to reduce the radiation buildup in the re-circulation modules a dropleg or some other method of transferring directly into the tank contents is recommended over the current practice of using a slurry distributor.
Operable Annulus Ventilation System	1.S10.2. Waste temperature shall not exceed 121°C (250 °F). 5.S1.1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top 4.6m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6m (15 ft). 5.S1.2. Temperature changeover time for solutions in tanks shall be ≤5.5°C (10 °F)/hr (<52°C [125 °F]) or ≤11°C (20 °F) /day (≥52°C [125 °F]) 5.S1.3. Temperature gradients of solution in tanks shall be ≤100°C/m (55 °F/ft) within the solution and at the solution/vapor interface	The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational and leak detection for the primary tank is provided by conductivity probes in the tank annulus.	It is not known at this time if the mixer pump operation will require a functional annulus exhaust system or if the system will be functional. Additional, refined thermal analysis for the retrieval functions to be performed in the 241-AZ tank farm need to be completed to confirm the preliminary calculations presented here.

Table 2-3. Ventilation System Issues and Recommendations. (4 Sheets)

Issue	Process need	Basis for issue	Suggested scope of work to address issue
Air In Leakage and Vacuum Control	Not process need but an operational control issue.	The primary tank air inlet stations are not now in operation and are valved shut. The inlet air is from air lift circulation (if operating) and outside air drawn into the tank through pit cover blocks, risers or uncapped transfer lines that are open to other sources such as the 241-AX-152 diverter station. If the in leakage air can be controlled to a minimal amount then the 702-AZ (W-030) primary tank air inlet stations can be utilized in the overall ventilation control	Perform analysis to determine if the existing air in leakage without flows through the W-030 installed air inlet stations woulld still allow acceptable control of ventilation system flow rates and negative pressure in the primary tank during waste feed delivery activities.
Thermal analysis of waste feed delivery activities relative to 241-AZ are preliminary in nature.	1.S10.2. Waste temperature shall not exceed 121°C (250 °F). 5.S1.1. Tank waste temperature shall be either: $\leq$90.6°C (195°F) in all levels of the waste; or $\leq$90.6°C (195°F) in the top 4.6 m (15 ft) of the waste and $\leq$102°C (215°F) in the waste below 4.6 m (15 ft). 5.S1.2. Temperature changeover time for solutions in tanks shall be $\leq$5.5°C (10 °F)/hr (<52°C [125 °F]) or $\leq$11°C (20 °F) /day ($\geq$52°C [125 °F]) 5.S1.3. Temperature gradients of solution in tanks shall be $\leq$100°C (55 °F)/ft within the solution and at the solution/vapor interface	The calculation does not account for temperature profiles within a non-convective layer of solids which would settle at the bottom of the tank. Duration of actual mixer pump operation is not yet well defined.	Additional, refined thermal analysis for the retrieval functions to be performed in the 241-AZ tank farm need to be completed to confirm the preliminary calculations presented here.

2.5 SAMPLING SYSTEM (Reserved)

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3.0 PROCESS DESCRIPTION

Both tanks in 241-AZ tank farm, 241-AZ-101 and 241-AZ-102, have been identified as HLW source tanks for feed delivery as part of Phase 1 privatization. The processing steps required to prepare the HLW feed from each of the tanks is discussed in Section 3.1 below. The transfer process of HLW from these source tanks to the private contractor is described in Section 3.2. Transfers associated with 241-C tank farm material to 241-AZ-101 via 241-AY-102 and miscellaneous transfers, not directly related to feed delivery, into or out of 241-AZ tank farm are also discussed in Section 3.2. Table 3-1 summarizes the process steps associated with each tank in 241-AZ tank farm during the Phase 1 privatization contract.

3.1 WASTE PREPARATION

The baseline presented in *Tank Waste Remediation System Retrieval and Disposal Mission Readiness-to-Proceed Memorandum* (Jordan and Boston 1998) called for the supernate in tanks 241-AZ-101 and 241-AZ-102 being LAW feed and pretreating the sludge as HLW feed. A waste feed preparation and delivery flowsheet describing the steps in making waste feed deliveries from tank 241-AZ-101 is described in *Volume II, Waste Feed Delivery Flowsheet* of the *Waste Feed Delivery Technical Baseline Document* (Papp 1998). The alternative case in DeLozier (1998) transfers the responsibility for washing the HLW sludge from the M&I contractor team to the private contractor. This eliminates the need for the M&I contractor team to establish sludge washing capability and instead requires the M&I contractor team to make more frequent (e.g., monthly) transfers. These transfers are slurry transfers requiring homogenous mixing to reduce feed variability to the private contractor. Water is added to retrieve the final batches of waste from 241-AZ-101.

The general waste preparation process steps described for 241-AZ-101 in the alternative case (DeLozier 1998) is also applicable to the waste currently in 241-AZ-102. Both 241-AZ-101 and 241-AZ-102 will be used as HLW feed staging tanks to the private contractor. These tanks will receive additional HLW currently in 241-AY-102, 241-C-106 and 241-C-104.

An assessment of the existing and planned waste feed preparation equipment is provided in Appendix A. Waste feed preparation equipment includes those pieces of equipment necessary to process the waste before to making a transfer.

Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm.

Tank	Process Step Required for Particular Tank (Yes/No)											
	Store waste	Prepare waste							Transfer waste			
	Safe storage	Degas feed	Separate solids and liquids	Soften crust	Dissolve solids	Mobilize solids	Suspend solids	Sample waste	Transfer liquid from tank	Receive liquid into tank	Transfer solids slurry from tank	Receive solids slurry into tank
241-AZ-101	Yes	No	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes
241-AZ-102	Yes	No	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes

3.2 WASTE TRANSFERS TO AND FROM 241-AZ

Waste transfers will occur to and from tank farm 241-AZ during the time frame of Phase 1 privatization. All waste transfers will be slurry transfers, rather than liquid transfers. It should be noted that both tanks in 241-AZ are HLW feed staging tanks to the private contractor and all HLW destined for the private contractor will be transferred through one of these two tanks. During Phase 1 privatization additional HLW will be transferred to 241-AZ via tank 241-AY-102 which will receive sluiced waste from tanks 241-C-106 and 241-C-104. Water is added to retrieve the final batches of waste being transferred from either tank in 241-AZ to the private contractor.

Appendix A provides a list of the set of transfers which are included in Appendix H of the *Tank Waste Remediation System Operation and Utilization Plan* (TWRSO&UP) (Kirkbride et al. 1997) specifically related to 241-AZ tank farm and also an updated set of transfers expected to be consistent with the alternative case in DeLozier (1998). The actual set of transfers and their timing associated with the case identified in DeLozier 1998 varies with those identified in the TWRSO&UP. The preliminary set of transfers based on DeLozier (1998) are used for the basis of this evaluation. The most notable differences relative to the baseline is that the alternative presented in DeLozier (1998) eliminates sludge washing and the associated transfers.

An assessment of the existing and planned waste transfer system is provided in Appendix A. Waste transfer equipment includes those pieces of equipment necessary to transfer the waste between tanks and include transfer pumps, piping, jumpers, and valving.

3.3 COMPARISON OF PROCESS STEPS TO FUNCTIONAL ANALYSIS

The preceding waste feed preparation steps are based on *Volume II, Waste Feed Delivery Flowsheet* of the *Waste Feed Delivery Technical Baseline Document* (Papp 1998). Waste transfers are based on the set of transfers consistent with DeLozier (1998). These process steps are not specifically based on the systems engineering functional analysis but are consistent with the functional analysis that is performed for Phase 1 privatization feed delivery. Tables 3-2 through 3-9 below map the process steps identified in Table 3-1 to the functional analysis documented in Attachment B of the *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components* (Claghorn et al. 1998). Tables 3-2 through 3-9 compare the process steps to the following functions:

Table 3-2	Function 3.2.1	Double-Shell Tank System
Table 3-3	Function 3.2.1.1	Maintain Safe and Compliant Waste within the Double-Shell Tank System
Table 3-4	Function 3.2.1.2	Deliver Low-Activity Waste Feed for Phase 1 Treatment

Table 3-5	Function 3.2.1.3	Deliver High-Level Waste Sludge to Low-Activity Waste/High-Level Waste Plant
Table 3-6	Function 3.2.1.4	Manage Double-Shell Tank Space
Table 3-7	Function 3.2.1.5	Receive Waste into Double-Shell Tanks
Table 3-8	Function 3.2.1.6	Distribute Utilities in Double-Shell Tank System
Table 3-9	Function 3.2.1.10	Support Double-Shell Tank System

Certain functions identified in Claghorn et al. (1998) are not applicable (N/A) to the specific processing associated with 241-AZ tank farm. As an example, the low activity waste feed delivery activity (function 3.2.1.2) does not have any functions which would rely upon 241-AZ tank farm for execution of the function.

Table 3-10 compares the architecture presented in Claghorn et al. (1998) to the organizational outline of the assessment presented in this document. The assessment is organized in this document according to waste preparation and transfer systems (Section 5.0), utilities distribution systems (Section 6.0), instrumentation, monitoring and control systems (Section 7.0), ventilation system (Section 8.0), and sampling system (Section 9.0). These systems are described in more detail in each of the sections of the document. The comparison in Table 3-10 shows that this assessment does not consider DST structures, potable water, or sewage because they do not fall within the scope of the assessment. Additionally, maintenance and recovery systems are not considered within the scope of this assessment.

Table 3-2. Comparison of Top Level System Assessment Process Steps in This Document to Level 3.2.1 Function, Double-Shell Tank System in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components,* HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998)						
3.2.1 Double-Shell Tank System						
3.2.1.1 Maintain Safe and Compliant Waste within the Double-Shell Tank System	3.2.1.2 Deliver Low Activity Waste Feed for Phase 1 Treatment	3.2.1.3 Deliver High-Level Waste Feed for Phase 1 Treatment	3.2.1.4 Manage Double-Shell Tank Space	3.2.1.5 Receive Waste into Double-Shell Tanks	3.2.1.6 Distribute Utilities in Double-Shell Tank System	3.2.1.10 Support Double-Shell Tank System
Store Waste	N/A	Prepare Waste/ Transfer Waste	Transfer Waste	Transfer Waste	N/A	N/A
Table 3-1, *Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery*, HNF-2941						

Table 3-3. Comparison of System Assessment Process Steps in This Document to 3.2.1.1 Maintain Safe and Compliant Waste within the Double-Shell Tank System Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998)										
3.2.1.1 Maintain Safe and Compliant Waste within the Double-Shell Tank System										
3.2.1.1.1 Store Waste in Double-Shell Tanks										
3.2.1.1.1.1 Contain Double-Shell Tank Waste	3.2.1.1.1.2 Control Double-Shell Tank and Waste Temperature	3.2.1.1.1.3 Control Double-Shell Tank and Waste Level and Density	3.2.1.1.1.4 Monitor Primary Tank for Leakage	3.2.1.1.1.5 Control Double-Shell Tank Corrosion	3.2.1.1.1.6 Control Air Emissions from Double Shell Tanks	3.2.1.1.1.7 Control Flammable Gas Concentrations in Double-Shell Tanks	3.2.1.1.1.8 Control Double-Shell Tank Vapor-Space Pressure	3.2.1.1.1.9 Control Primary to Annulus Differential Pressure	3.2.1.1.1.10 Monitor Double- Shell Tank Waste Storage Parameters at Central Monitoring Station	3.2.1.1.1.11 Monitor Double-Shell Tank Area Radiation Levels
Safely Store Waste										
Store Waste										
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm										
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941										

Table 3-4. Comparison of System Assessment Process Steps in This Document to 3.2.1.2 Deliver Low Activity Waste Feed for Phase 1 Treatment Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998)					
3.2.1.2 Deliver Low Activity Waste Feed for Phase 1 Treatment					
3.2.1.2.1 Prepare Low Activity Waste Supernatant for Transfer	3.2.1.2.2 Transfer Low Activity Waste Supernatant to Staging Tanks	3.2.1.2.3 Prepare Low Activity Waste Salts for Transfer	3.2.1.2.4 Transfer Low-Activity Waste Salt Solution to Staging Tanks	3.2.1.2.5 Blend Low Activity Waste in Low-Activity Waste Staging Tanks	3.2.1.2.6 Transfer Low-Activity Waste to Vendor Feed Storage
N/A	N/A	N/A	N/A	N/A	N/A
N/A					
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm					
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941					

Table 3-5. Comparison of System Assessment Process Steps in This Document to 3.2.1.3 Deliver High-Level Waste Sludge to Low-Activity Waste/ High-Level Waste Plant Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998)	
3.2.1.3 Deliver High-Level Waste Sludge to Low-Activity Waste/High-Level Waste Plant	
3.2.1.3.1 Prepare High-Level Waste Solids for Transfer	3.2.1.3.2 Transfer High-Level Waste Sludge to Low-Activity Waste/High-Level Waste Plant
Add Diluent, Mix Tank Contents, Sample Waste	Transfer Solids Slurry from Tank
Prepare Waste	Transfer Waste
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm	
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941	

Table 3-6. Comparison of System Assessment Process Steps in This Document to 3.2.1.4 Manage Double-Shell Tank Space Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery,* HNF-1985 (Claghorn et al. 1998)			
3.2.1.4 Manage Double-Tank Space			
3.2.1.4.1 Prepare Waste in Double-Shell Tank	3.2.1.4.2 Transfer Waste Between Double-Shell Tanks Inside Areas	3.2.1.4.3 Transfer Waste Cross-Site Between Double-Shell Tanks	3.2.1.4.4 Transfer Waste for Concentration
N/A	Transfer Solids Slurry from Tank, Receive Solids Slurry into Tank	Receive Solids Slurry into Tank	N/A
N/A	Transfer Waste		N/A
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm			
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941,			

Table 3-7. Comparison of System Assessment Process Steps in This Document to 3.2.1.5 Receive Waste into Double-Shell Tanks Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998)				
3.2.1.5 Receive Waste into Double-Shell Tanks				
3.2.1.5.1 Receive Waste from Waste Unloading Facility	3.2.1.5.2 Receive New Liquid Waste from External Waste Generators	3.2.1.5.3 Receive Concentrated Waste from Evaporator	3.2.1.5.4 Receive Emergency Purge Waste from Evaporator	3.2.1.5.5 Receive Waste Products from Low Activity Waste / High Level Waste and Low Activity Waste Treatment
N/A	Receive Solids Slurry into Tank	N/A	N/A	N/A
N/A	Transfer Waste	N/A		
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm				
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941.				

Table 3-8. Comparison of System Assessment Process Steps in This Document to 3.2.1.6 Distribute Utilities in Double-Shell Tank System Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985 (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998)		
3.2.1.6 Distribute Utilities in Double- Shell Tank System		
3.2.1.6.1 Provide Electrical Power	3.2.1.6.2 Provide Water	3.2.1.6.3 Provide Compressed and Instrument Air
N/A	N/A	N/A
N/A*		
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm		
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941		

*"Distribute Utilities in Double-Shell Tank System" is not considered a process step in the context of HNF-2983. Utilities are discussed in Section 6 of HNF-2983.

Table 3-9. Comparison of System Assessment Process Steps in This Document to 3.2.1.10 Support Double-Shell Tank System Function in Attachment B of *Review of Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985, (Claghorn et al. 1998).

Attachment B, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998)
3.2.1.10 Support Double-Shell Tank System
N/A
N/A*
Table 3-1. Matrix of Process Steps for Each Tank in 241-AZ Tank Farm
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941

*"Support Double-Shell Tank System" is not considered a process step in the context of HNF-2983.

Table 3-10. Comparison of System Assessment Structures, Systems and Component Categorization in This Document to System Architecture Tree in *Review of Performance Requirements for Phase 1 Waste Feed Delivery*, HNF-1985 (Claghorn et al. 1998).

HNF-1985, *Review of Performance Requirements for Phase 1 Waste Feed Delivery*																		
System Architecture Tree																		
1. DST Storage System			2. DST Transfer System					3. Waste Preparation Equipment			4. DST Monitor & Control System	5. DST Utility Distribution System						6. Maintenance and Recovery System
1.1 DST Structure	1.2 DST I&C	1.3 DST Ventil-ation	2.1 Decant Pump	2.2 Slurry Pump	2.3 Piping Network	2.4 Slurry Distributor	2.5 Supernate Pump	3.1 Mixer Pump	3.2 Chemical Addition System	3.3 Sonic Probe		5.1 Compressed Air	5.2 Potable Water	5.3 Raw Water	5.4 Electrical	5.5 Sewage	#	
*			5.2 Transfer Pumps and Piping and Valve Routings	5.2 Transfer Pumps and Piping and Valve Routings	5.2 Transfer Pumps and Piping and Valve Routings	5.2 Transfer Pumps and Piping and Valve Routings	5.2 Transfer Pumps and Piping and Valve Routings	5.1 Mixer Pumps	5.3 Chemical Addition and Flushing Systems	7.0 Instru-mentation & Control		6.1 Compressed / Instrument Air System	*	6.2 Raw Water Supply	6.3 Electrical Power Distribution System	*	6.4 Steam System	*
*	7.0 Instru-menta-tion & Control	8.0 Ventil-ation	5.0 Waste Preparation and Transfer Systems					5.0 Waste Preparation and Transfer Systems			7.0 Instru-mentation & Control	6.0 Utility Distribution Systems						
Document Sections Discussing Structures, Systems and Components in 241-AZ Tank Farm, HNF-2941																		
Evaluation of 241-AZ Tank Farm Supporting Phase 1 Waste Feed Delivery, HNF-2941																		

#Does not appear in System Architecture Tree in HNF-1985.
*Does not appear in Structure, System, and Component Assessment in HNF-2941.

4.0 IDENTIFICATION OF PROCESS NEEDS

The process needs associated with waste processing and tank-to-tank transfers at 241-AZ tank farm to support feed delivery to the private contractor in support of Phase 1 privatization are identified within this section of the document. Quantified process needs are identified where available. However, an adequate technical basis does not exist in all cases to provide quantified limits. In these cases qualitative needs are identified which require a further level of analysis than available at the time of this evaluation to establish technically based quantitative needs.

Process needs will vary according to the activity or process step being performed. Process needs are grouped according to process step. The process steps which will be used for categorizing the process needs are the process steps identified in Table 3-1 above, namely: safe storage; add diluent; mix tank contents; sample waste; transfer solids slurry from tank; transfer solids slurry to tank.

The scope of this evaluation is limited to process needs associated with 241-AZ tank farm during the Phase 1 privatization. The scope is consistent with the alternative case identified in DeLozier 1998. The time frame examined is through 2016. The SSCs examined are associated with waste preparation and transfer, utilities, instrumentation and control, ventilation and sampling. Table 4-1 presents process needs associated with the various operational steps which will be completed in tanks 241-AZ-101 and 241-AZ-102 (refer to Table 3-1 above). For each quantitative process need a technical basis is identified as well as the systems which are affected or required to meet the process need. Where information is not available to define or establish a quantitative process need, an issue is identified.

Additionally, this evaluation identifies existing safety-related needs applicable to current operation (i.e., safe storage) of 241-AZ tank farm. These authorization basis requirements are based on the existing set of technical safety requirements for tank farm operations and are not intended to be a complete set of safety-related requirements which will be in place during Phase 1 privatization activities. An initial assessment of the safety-related requirements for waste feed delivery (Grams et al. 1997) has been completed and additional work is ongoing to establish safety-related requirements. However, this work is not complete. Table 4-2 presents current safety requirements that may be associated with the various operational steps which will be completed at 241-AZ tank farm during Phase 1 privatization feed delivery (refer to Table 3-1 above). These safety-related requirements are included here as an assumed minimum set of safety-related needs expected during Phase 1 privatization.

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
1. Safe Storage	None (see Table 4.2)			
2. Degas Feed	P1. Remove trapped flammable gases from waste prior to transfer to eliminate or reduce probability of occurrence of a gas release event.	1. Reserved (None)		
		2. Reserved (None)		
	P2. Control rate of gas release from flammable gas watch list tanks.	1. Reserved (None)		
		2. Reserved (None)		
		3. Reserved (None)		
		4. Reserved (None)		
		5. Reserved (None)		
		6. Reserved (None)		
		7. Reserved (None)		
3. Separate Solids and Liquids	P1. Provide LAW feed to the private contractor within the contract envelope limits for insoluble solids.	1. Reserved (None)		
4. Dissolve Solids	P1. Dissolve soluble precipitated salts in selected DSTs. Selected DSTs are 241-AN-103, AN-104, AN-105, AW-101, SY-101, and SY-103.	1. Reserved (None)		
		2. Reserved (None)		
		3. Reserved (None)		
		4. Reserved (None)		
		5. Reserved (None)		

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P2. Allow operation of equipment (bottom thermocouples, mixer pumps, decant pumps, slurry transfer pumps)	1. Reserved (None)		
		2. Reserved (None)		
		3. Reserved (None)		
	P3. Retrieve waste from multiple tanks as needed to support waste feed delivery schedule.	1. Reserved (See 5B.P4.1)		
5A.Mobilize Solids	P1. Transfer solid particles from a static settled state solid phase to a dynamic state.	1. Mobilize >90% of the solids initially in 241-AZ-101, >60% of the solids initially in 241-AZ-102, and >99% of the solids transferred to these tanks from 241-AY-102.	Mobilization efficiencies are based on experimental Effective Cleaning Radius (ECR) data for two symmetrically located mixer pumps with U_0D of 29.4 ft^2/sec and TCR data for the tank wastes. (see appendix F.1.21) For solids transferred from 241-AY-102, these solids were suspended by mixer pumps to be transferred and it is anticipated the mobilization, suspension and transfer characteristics will be similar for 241-AY-102 and the two 241-AZ tanks.	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 3.1 Mixer Pump)
	P2. Reserved			
	P3. Prevent components from exceeding operating parameters for the system	1. Equipment used to suspend or mobilize waste shall be able to operate under both normal startup and operation conditions (Note: for the currentlly planned system - Prevent cavitation of the mixer pump during normal startup and operation conditions).	Pump cavitation can damage the mixer pump. Relevant waste properties include non-Newtonian viscosities from TBD to 50 cP at 100 sec^{-1} shear rate. The NPSHa is 5.2 m (17 ft). This assumes a liquid level in the tank 1.1 m (3.5 ft) above the pump suction, a maximum waste temperature of 185 °F, and atmospheric pressure of 10 m (33 ft) of water.(WHC-SD-WM-DGS-006, Rev. 0) (see Appendix F.1.5)	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 3.1 Mixer Pump)
		2. Reserved		

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		3. Equipment used to mobilize or suspend waste shall not impart excessive force to the tank structure. (Note: for the currently planned system - Provide mixer pumps which will not damage the tank structure during normal and/or off-normal operation.)	The tank structure, risers, and pits must not be damaged by operation of the mixer pump (WHC-SD-WM-DGS-006, Rev. 0)	Waste Preparation and Transfer (1.1 DST Structure)
		4. Provide a diluent system and water addition line to allow addition of up to 341 m³ (90,000 [TBR] gal) raw water near the intake of each mixer pump. The dilution system should be capable of providing this quantity at a flow rate of TBD gal/min and a temperature range of 20 °C to 50 °C (+/- TBD °C). No cooling capacity is required.	Provides both a flushing capability to reduce concentration of saturated salts near the pump intake and provides a means to dilute the slurry concentration near the intake to minimize pump cavitation during startup. (see Appendix F.1.6)	Waste Preparation and Transfer, Instrumentation and Control, Utility Distribution (1.2 DST I&C, 3.1 Mixer Pump, 3.2 Chemical Addition System, 5.3 Raw Water)
		2. Provide a diluent system and water addition line to allow addition of up to 379 m³ (100,000 gal) raw water near the intake of each mixer pump. The dilution system should be capable of providing this quantity at a flow rate of TBD gal/min and a temperature range of 20 °C to 50 °C (+/- TBD °C). No cooling capacity is required.	Provides both a flushing capability to reduce concentration of saturated salts near the pump intake and provides a means to dilute the slurry concentration near the intake to minimize pump cavitation during startup. (see Appendix F.1.6)	Waste Preparation and Transfer, Instrumentation and Control, Utility Distribution (1.2 DST I&C, 3.1 Mixer Pump, 3.2 Chemical Addition System, 5.3 Raw Water)
		5. Control the rate of operation of equipment used to mobilize and suspend solids. (Note: for the currently planned system - Provide mixer pumps with a variable frequency drive (VFD) capable of operating the pump from a minimum speed of approximately 58% speed to full speed operation.)	This provides the flexibility to allow a slow start during initial mobilization to minimize cavitation. (WHC-SD-WM-DGS-006, Rev. 0)	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 3.1 Mixer Pump)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		6. Provide in-tank components which can withstand forces imparted by solids mobilization and suspension equipment and remain operable and retrievable from the DST. (Note: for the currently planned system - Provide (or replace) in-tank components which can withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST)	Operation of mixer pumps must not cause in-tank components to fail or bend them such that they can not be retrieved. (WHC-SD-WM-DGS-006, Rev. 0). A documented assessment is needed to justify not meeting this process need for specific components.	Waste Preparation and Transfer (1.2 DST I&C, 2.1 Decant Pump, 2.2 Slurry Pump, 2.5 Supernate Pump)
		7. Provide solids mobilization and suspension equipment which will not damage the tank structure during normal and/or off-normal operation. (Note: for the currently planned system - Provide mixer pumps which will not damage the tank structure during normal and/or off-normal operation.)	The tank structure, risers, and pits are considered Safety Class or safety significant and thus must not be damaged by operation of the mixer pump. (WHC-SD-WM-DGS-006, Rev. 0)	Waste Preparation and Transfer (1.1 DST Structure)
		8. Monitor the rate of operation of equipment used to effect solids mobilization and suspension. (Note: for the currently planned system - Provide, at a minimum, the following mixer pump instrumentation: remote readout of pump motor amperage, shaft rotational speed, and nozzle orientation.)	Pump motor amperage may be obtained through the VFD. Provides indication of motor condition and pump operating parameters. Shaft rotational speed provides indication of pump operating parameters. Nozzle orientation is required to allow flexibility to direct nozzle flows toward or away from areas of interest. (WHC-SD-WM-DGS-006, Rev. 0)	Instrumentation and Control (1.2 DST I&C)
5B. Suspend Solids	P1. Suspend mobilized solid particles in the liquid phase. (Note: for currently planned system - Mixer pump operation should mix liquids and suspend mobilized solids uniformly throughout the waste solution.)	1.Reserved		

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		2. Mix tank contents to provide <TBD% variability of suspended HLW solids concentrations over the full depth prior to sampling and prior to beginning each feed transfer.	Representative samples are necessary to qualify the waste for transfer to the privatization contractor. Mixing the tank minimizes the number of required samples. Minimizing the variability of the individual waste feed batches to the Privatization Contractor is necessary for material accountability and to simplify waste formulation and process control. A variability of <TBD% for a few key analytes is considered homogeneous per the HLW Transfer Problem Specific DQO (Certa et. al. 1998, HNF-XXX, TBP)	Waste Preparation and Transfer, Instrumentation and Control, Ventilation (1.2 DST I&C, 3.1 Mixer Pump)
	P2. Add diluent to allow operation of equipment	1. Provide capability for addition of 379 m^3 (100,000 gal) of inhibited water to 241-AZ-101 and 241-AZ-102 for each of the final two slurry transfers to the Privatization Contractor. The inhibited water shall meet the minimum corrosion specifications of 0.01M OH^- and 0.011M NO_2^-.	The nominal transfer volume is 379 m^3 (100,000 gal). The transfer solution will only be added when tank level gets below 102 cm (40 in.). At waste levels below this point the mixer pumps are expected to cavitate. (see Appendix F.1.20)	Waste Preparation and Transfer, Utility Distribution, Instrumentation and Control (1.2 DST I&C, 3.2 Chemical Addition System, 5.3 Raw Water)
	P3. Reserved.			

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P4. Retrieve waste from multiple tanks as needed to support waste feed delivery schedule.	1. Provide for the independent operation of one set of mixer pumps in each of four 200 East Area DST farms and one transfer pump in a 200 East Area DST farm. Provide control systems and electrical distribution systems which can support the simultaneous operation of up to nine mixer pumps and one transfer pump.	Integrated schedules show that at least once in each of the first three years of processing, up to nine mixer pumps and one transfer pump may be needed simultaneously (DeLozier to Umek, letter no. LMHC-9854671A R1, attachment 1). Potentially simultaneous operations include 1) transfer HLW from 241-AY-102 to one of the 241-AZ tanks (four 112-kW [150-hp] mixer pumps and one 45-kW [60-hp] transfer pump in 241-AY-102), 2) mixing of HLW in one of the 241-AZ tanks in preparation for transfer to the Privatization Contractor (two 224-kW [300-hp] mixer pumps), 3) degassing or solids dissolution in 241-AN-105 or 241-AN-104 (two 224-kW [300-hp] mixer pumps), and 4) mixing and sampling of LAW feed in 241-AP-102 or 241-AP-104 (one 224-kW [300-hp] mixer pump).	Utility Distribution, Instrumentation and Control (1.2 DST I&C, 5.4 Electrical)
6. Sample Waste	P1. Ensure compatibility between sending and receiving tanks	1. Provide capability for taking multiple representative grab samples of the waste from one or more risers. Waste compatibility testing is performed per existing DQOs.	HNF-SD-WM-DQO-001, *Data Quality Objectives for Tank Farm Waste Compatibility Program*	Sampling System and Analysis System (1.1 DST Structure)
	P2. Confirm waste composition and inventory within contract specifications	1.Reserved		

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		2. The total sample volume, will meet the sample volume needs for: analysis of the tank waste to support feed certification, a sample to BNFL, and archive sample material. The tank waste sample provided to BNFL will contain at least 200 grams of solids. Tank waste conditions such as temperature and tank volume will be identified at the time of sampling. Samples of each HLW feed tank will be provided to the privatization contractor at least 30 days prior to the first transfer of such waste to the contractor's feed tank and no later than 5 days after sampling of the feed batch.	TWRS-P Project Interface Control Document, BNFL-5193-ID-20, Rev. 2.	Sampling, Instrumentation and Control (1.1 DST Structure, 1.2 DST I&C)
		3. The HLW tank waste sampling method (core sampling or grab sample techniques) will be established for each tank waste based upon the waste characteristics and capability of the system. Immediately following the shutdown of the mixer pump, approximately equal volume grab samples of waste material will be obtained from every 0.61 m (2 ft) of waste height from below a single riser for a grab sampling technique. (For a core sampling techynique a core the entire height of the tank waste will be obtained).	TWRS-P Project Interface Control Document, BNFL-5193-ID-20, Rev. 2. Either grab sample or core sampling techniques are allowable to sample tank contents.	Sampling (1.1 DST Structure)
7. Transfer Supernate from Tank	P1. Avoid solids accumulation which could plug the transfer line. Avoid solids precipitation during transfer due to cooling or dilution	1. Reserved (None)		
	P2. Remove targeted waste volumes/levels.	Reserved (None)		
	P3. Prevent components from exceeding operating parameters for the system.	Reserved (None)		

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P4. Capability to flush the transfer lines with inhibited water.	Reserved (None)		
8. Receive Supernate into Tank	P1. Do not overfill tank.	Reserved (None)		
9. Transfer Solids Slurry from Tank	P1. Avoid solids accumulation which could plug the transfer line.	1. Provide transfer system capable of achieving a waste transfer velocity of 1.8 to 2.7 msec (6 to 9 ft/sec).	This transfer velocity provides sufficient energy to keep all expected solids suspended during the waste transfer without causing excessive erosion within the piping system (Rockwell 198x).	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 2.2 Slurry Pump)
		2. Provide transfer pumps with a water addition feature that will provide slurry dilution capability at the pump suction. The needed dilution water flow rate is 530 L/min (140 gal/min).	Provides a means to dilute the slurry concentration near the pump intake if line pressure and flowrate indicate that a line blockage is forming. Dilution water flowrate equivalent to the minimum design flow rate allows flow to be established with dilution water prior to transferring waste. This also allows the capability to continue to operate the pump without terminating a transfer if blockage is thought to be forming. The minimum acceptable linear flow rate for slurries is 1.8 m/s (6 ft/s) (Rockwell 198x) which is equivalent to 530 m^3/min (140 gal/min) through a 7.6-cm (3-in.) SCH-40 pipe.	Waste Preparation and Transfer, Instrumentation and Control, Utility Distribution (1.2 DST I&C, 2.2 Slurry Pump, 3.2 Chemical Addition System, 5.3 Raw Water)
	P2. Remove targeted waste volumes/levels.	1. Determine total HLW solids mass (expressed as non-volatile oxides) transferred to the Privatization Vendor to within a variability of TBD%.	The accuracy will be determined based on best reasonably achievable sampling and analysis. Specific requirements will be developed as part of the HLW Transfer Problem-Specific DQO (TBP, Certa, et. al, 1998, HNF-XXX)	Instrumentation and Control, Sampling (1.2 DST I&C)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P3. Prevent components from exceeding operating parameters for the system	1. In normal operation, maintain the transfer system pressure drop below the transfer line operating pressure. The maximum line operating pressure can vary between 16.9 to 28.2 kPa (230 to 400 psi) depending on the transfer line.	The transfer system needs to be designed to either limit the maximum provided pump head below such that the maximum operating pressure can not be exceeded or a provide a pressure relief mechanism. In the past, the tested operating pressure has varied from 16.9 kPa (230 psi) to the current 28.2 kPa (400 psi) based on tank farm construction specification B-131-C1, Section 15490, Pipe Code M-25.	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 2.2 Slurry Pump, 2.3 Piping Network)
		2. Provide transfer pumps with a maximum design head of 137 m (450 ft) (TBR) total dynamic head at the target flow rate of 530 L/min (140 gal/min).	The operating philosophy is that a transfer pump be sized to meet the head requirements for the longest expected routing. For transfers with less head loss, a variable speed device is used to lower the pump's operating curve to the system curve so that operation is near the best efficiency point.(WHC-SD-WM-DGS-006, Rev. 0) (see Appendix F.1.13)	Waste Preparation and Transfer (2.2 Slurry Pump)
		3. Equipment used to transfer waste shall be able to operate under both normal startup and operation conditions. (Note: for the currently planned system, prevent cavitation of the transfer pump during normal startup and operation conditions. Net positive suction head required should not exceed Net Positive Suction Head Available at highest reasonable operating temperatures.)	Pump cavitation can damage the transfer pump. Relevant waste properties are determined for each transfer. (WHC-SD-WM-DGS-006, Rev. 0)	Waste Preparation and Transfer (2.2 Slurry Pump)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		4. Control the rate of operation used to transfer. (Note: for the currently planned system, provide transfer pumps with a VFD capable of operating the pump from a minimum speed of approximately 25% speed to full speed operation.)	This provides the flexibility to allow a slow start during startup to allow fluids to reach process-lubricated bearings prior to full speed operation. Variable speeds on transfer pumps enhance pump life by allowing them to be operated at a speed which will achieve the desired waste flow rate while running the pump near its best efficiency point. (WHC-SD-WM-DGS-006, Rev. 0).	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 2.2 Slurry Pump)
		5. Protect equipment from off normal transfer conditions. (Note: for the currently planned system, provide reverse rotation and back flow protection for transfer pumps.)	Reverse flow can result from back flushing prior to startup and after shutdown, drain back due to transfer line holdup and elevation differences when pump is shut off, and incorrect phase connection during wiring. (WHC-SD-WM-DGS-006, Rev. 0).	Waste Preparation and Transfer (2.2 Slurry Pump)
		6. Provide in-tank components that can withstand forces imparted by mobilization and suspension equipment and remain operable and retrievable from the DST. (Note: for the currently planned system, provide slurry transfer pumps which can be operated during mixer pump operation and withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST	Minimization of feed batch variability necessitates that the transfer pump operates while the mixer pumps are operating to maintain a uniform waste suspension. Operation of mixer pumps must not cause the transfer pump to fail or bend such that it can not be retrieved. (see Appendix F.1.14)	Waste Preparation and Transfer (2.2 Slurry Pump)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
		7. Monitor equipment to maintain system in operation. (Note: for the currently planned system, identify impending pump failure as soon as possible. Transfer pumps should be instrumented, at a minimum, to provide remote readout of pump motor amperage and shaft rotational speed.	Indication of impending pump failure will be used to initiate preparation for pump replacement (waste feed transfers will usually be on the critical path). (see appendix F.1.15 regarding running a transfer pump to failure) Pump motor amperage may be obtained through the VFD. It provides indication of motor condition and pump operating parameters. Shaft rotational speed provides indication of pump operating parameters. Pump motor winding and bearing temperatures exceeding equipment specifications can be indication of impending pump failure.	Instrumentation and Control (1.2 DST I&C)
		8. Provide transfer system components capable of transferring waste with a density as high as 1.4 g/ml.	This is the maximum waste density expected to be produced for transfer. Densities greater than this generally contain precipitated major sodium salts. HLW slurry transfers will generally be less than 1.2 g/ml. (see appendix F.1.18)	Waste Preparation and Transfer (2.0 DST Transfer System)
		9. Provide transfer system components capable of handling wastes with a pH of 7 (TBR) or greater.	All waste will be on the basic side. Raw water will have a pH as low as 7 (WHC-SD-WM-DGS-006, Rev. 0). The pH of raw water from the Columbia River typically ranges from TBD. (see appendix F.1.16)	Waste Preparation and Transfer (2.0 DST Transfer System)
		10. Provide a transfer system which prevents the occurrence of water hammer resulting from reconfiguration of the system during the transfer.	Water hammer can damage the integrity of the transfer system and should be avoided to the extent possible by system design and operational controls.	Waste Preparation and Transfer (2.0 DST Transfer System)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P4. Capability to flush the transfer lines with inhibited water.	1. Provide a diluent system to flush the transfer lines with inhibited water at 530 L/min (140 gal/min) (TBR).	Flushing of the transfer lines is necessary to remove any deposited solids and to flush high ionic strength waste out of the lines to avoid line pluggage and minimize corrosion. The identified flow rate provides the ability to flush the transfer lines at a flow rate that is equivalent to the actual transfer activity. (see appendix F.1.3 and F.1.4)	Waste Preparation and Transfer, Instrumentation and Control, Utility Distribution (1.2 DST I&C, 2.0 DST Transfer System, 3.2 Chemical Addition System, 5.3 Raw Water)
		2. The flush direction should be from the applicable 241-AZ pump pit to the Privatization Contractor facility (TBR).	The current W-314 design is configured to drain from the HLW privatization contractor interface back to 241-AZ.. Interfaces with the privatization contractor have not been finalized. therefore assume that PHMC must provide flushing capability. (see Appendix F.1.19)	Waste Preparation and Transfer (2.3 Piping Network, 3.2 Chemical Addition System)
		3. Flush transfer lines with water volumes equivalent to 1.5 times the transfer line internal volume.	The standard flush volumes are 1-2 equivalent line volumes. (see appendix F.1.17)	Waste Preparation and Transfer, Instrumentation and Control, Utility Distribution (1.2 DST I&C, 3.2 Chemical Addition System, 5.3 Raw Water)
		4. Flush water inlet can be at the transfer pump inlet or in the pump discharge line.	The flush water will serve the same purpose with either inlet point. (see appendix F.1.19)	Waste Preparation and Transfer (2.2 Slurry Pump, 2.3 Piping Network)
10. Receive Solids Slurry into Tank	P1. Do not overfill tank	1. Provide tank level monitoring and alarm systems	Tank level monitoring is a standard material balance approach for monitoring progress of a waste transfer. Material balance calculations are used for detection of leaks or misroutings per HNF-SD-WM-TSR-006, 5.12.2.b. (see Table 4.2 Safety Requirement 7.S1.1)	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)

Table 4-1. Process Needs Assessment for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Basis	Affected systems (applicable SSCs)
	P2. Minimize generation of aerosols in 241-AY and 241-AZ Tank Farms	1. In 241-AZ and 241-AY tanks, provide a drop leg or other method of discharging liquid beneath tank waste surface.	HNF-2783, *Slurry Distributor Affects on Ventilation System*, Unacceptably high radiation fields would be produced in the 702-AZ ventilation system ductwork and piping resulting from settling out of aerosols generated by waste discharges into the tank headspace.	Waste Preparation and Transfer (2.3 Piping Network, 2.4 Slurry Distributor)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
1. Safe Storage	S1. Manage flammable gas hazards	1. Reserved		
		2. Manage tanks AZ-101 and AZ-102 as Facility Group 2 assignments.	HNF-SD-WM-TSR-006, Rev. 0, Section 5.9, Administrative Controls, Flammability Controls	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 2.1 Decant Pump, 2.5 Supernate Pump, 3.2 Chemical Addition System, 4.0 DST Monitor and Control System)
		3. Maintain flammable gases concentrations no greater than 25% of the lower flammability limit	HNF-SD-WM-TSR-006, Rev. 0, Section 5.9, Administrative Controls, Flammability Controls	Waste Preparation and Transfer, Instrumentation and Control, Ventilation (1.2 DST I&C, 1.3 DST Ventilation, 3.1 Mixer Pump, 4.0 DST Monitor and Control System)
	S2. Manage potential ignition sources that can initiate a fire or flammable gas deflagration.	1. Reserved		
		2. Flammable gas ignition source controls for Tanks AZ-101 & AZ-102 are Facility Group 2 requirements.	HNF-SD-WM-TSR-006, Rev. 0, Section 5.10, Administrative Controls, Ignition Controls	Waste Preparation and Transfer (2.1 Decant Pump, 2.5 Supernate Pump, 3.2 Chemical Addition System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
		3. An active primary ventilation system shall be operable for all DSTs and AWF tanks	Limiting condition for operation (LCO) 3.2.1, active ventilation provides control of airborne contamination, active ventilation also serves to maintain flammable gas concentrations below 25% of the LFL.	Ventilation, Instrumentation and Control (1.2 DST I&C, 1.3 DST Ventilation, 4.0 DST Monitor and Control System)
	S3. Monitor flammable gas concentrations to prevent deflagration	1. Reserved		
	S4. Provide operable transfer system covers	1. Transfer system covers associated with structures that are physically connected to an active waste transfer pump not under administrative lock or under the control of AC 5.22, "Transfer System Cover Removal Controls" shall be operable.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.1.1, Limiting Conditions for Operation, Transfer System Covers	Waste Preparation and Transfer (1.1 DST Structure)
	S5. Provide service water pressure detection	1. Service water pressure detection systems that are physically connected to an active waste transfer pump not under administrative lock shall be operable.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.1.2, Limiting Conditions for Operation, Service Water Pressure Detection Systems	Utility Distribution Instrumentation and Control (1.2 DST I&C, 2.1 Decant Pump, 2.2 Slurry Pump, 2.5 Supernate Pump, 3.2 Chemical Addition System, 4.0 DST Monitor and Control System, 5.3 Raw Water)
	S6. Provide transfer leak detection	1. Leak detection in all process pits, diversion boxes, vault pits, and cleanout boxes physically connected to an active waste transfer pump that is not under administrative lock shall be operable.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.1.3, Limiting Conditions for Operation, Transfer Leak Detection Systems	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
	S7. Provide ventilation stack continuous air monitor (CAM) interlock systems	1. Primary tank ventilation stack CAM interlock systems shall be operable when active ventilation is operating.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.1.4, Limiting Conditions for Operation, Ventilation Stack Continuous Air Monitor Interlock Systems	Instrumentation and Control, Ventilation (1.3 DST Ventilation, 4.0 DST Monitor and Control System)
	S8. Provide tank ventilation	1. An active primary tank ventilation system for DSTs and AWF tanks shall be operable.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.2.1, Limiting Conditions for Operation, DST and AWF Tank Ventilation Systems	Ventilation, Instrumentation and Control (1.3 DST Ventilation, 4.0 DST Monitor and Control System)
	S9. Provide primary tank leak detection	1. Either the annulus conductivity probe system or the annulus continuous air monitor system shall be operable for DSTs and AWF tanks.	HNF-SD-WM-TSR-006, Rev. 0, Section 3.2.6, Limiting Conditions for Operation, Primary Tank Leak Detection Systems	Ventilation Instrumentation and Control (1.2 DST I&C, 1.3 DST Ventilation, 4.0 DST Monitor and Control System)
	S10. Control tank waste temperature	1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top 4.6 m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6 m (15 ft).	HNF-SD-WM-TSR-006, Rev. 0, Section 3.3.2, Limiting Conditions for Operation, DST and AWF Tank Waste Temperature Controls, prevents tank bump or steam release event, protects against a postulated "chemical runaway" accident (Organic Salt-Nitrate Reaction)	Ventilation, Instrumentation and Control (1.2 DST I&C, 1.3 DST Ventilation, 4.0 DST Monitor and Control System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
		2. Waste temperature shall not exceed 121°C (250 °F).	BIO Safety Limit 2.1.1	Ventilation, Instrumentation and Control (1.2 DST I&C, 1.3 DST Ventilation, 4.0 DST Monitor and Control System)
	S11. Prevent primary tank overfilling	1. Provide instrumentation, monitoring and controls for service water to avoid overfilling a waste tank in the event of a water line break.	A service water flow totalizer is specified by the BIO (pg. 5.4-58) as a preventative and mitigative SSC against a water line break overfilling a tank.	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)
	S12. Prevent subsurface release of radioactive materials due to leaks in multiple tanks.	1. Provide primary tank leak detection, tank level monitoring, and temperature monitoring, and transfer controls on waste pH.	Controls and Instrumentation specified by the BIO (pg. 5.4-153) to prevent and mitigate leaks resulting from tank and tank component corrosion. Temperature monitoring prevents one possible cause of tank failure and is a possible indicator of tank heat up resulting from a leak.	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
4. Add Diluent to Tank	S1. Prevent contamination of service water systems	1. Prevent backflow of waste from active waste transfer pump into service water systems that are physically connected during transfer	TSR Control LCO 3.1.2 requires that service water pressure detection systems be operable. Flushing system pressure switches and associated interlocks with waste transfer pumps or alarm response are used to stop inadvertent waste flow into flushing systems in transfer-associated structures that do not have covers. This prevents potential leaks from developing outside the transfer path. The pressure switches and associated interlocks or alarm response also prevent radioactive material from contaminating the service water supply system.	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 3.2 Chemical Addition System)
5. Mix Tank Contents	S1. Control tank waste temperature	1. Tank waste temperature shall be either: $\leq$90.6°C (195°F) in all levels of the waste; or $\leq$90.6 (195°F) in the top 4.6 m (15 ft) of the waste and $\leq$102°C (215°F) in the waste below 4.6 m (15 ft).	HNF-SD-WM-TSR-006, Rev. 0, Section 3.3.2, Limiting Conditions for Operation, DST and AWF Tank Waste Temperature Controls, prevents tank bump or steam release event, protects against a postulated "chemical runaway" accident (Organic Salt-Nitrate Reaction)	Ventilation, Instrumentation and Control, Waste Preparation and Transfer (1.2 DST I&C, 1.3 DST Ventilation, 3.1 Mixer Pump, 4.0 DST Monitor and Control System)
		2. Temperature changeover time for solutions in tanks shall be $\leq$5.5°C (10 °F)/hr (<52°C [125 °F]) or $\leq$11°C (20 °F)/day ($\geq$52°C [125 °F])	OSD-T-151-00007, rev H-19, Waste temperatures are limited to prevent excessive stress to the primary tank and structural degradation of the concrete shell. High temperatures, rapid temperature cycling and extreme temperature gradients can cause concrete deterioration and cracking.	Ventilation, Instrumentation and Control, Waste Preparation and Transfer (1.2 DST I&C, 1.3 DST Ventilation, 3.1 Mixer Pump, 4.0 DST Monitor and Control System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
		3. Temperature gradients of solution in tanks shall be ≤102°C/m (55 °F/ft) within the solution and at the solution/vapor interface	OSD-T-151-00007, rev H-19, Waste temperatures are limited to prevent excessive stress to the primary tank and structural degradation of the concrete shell. High temperatures, rapid temperature cycling and extreme temperature gradients can cause concrete deterioration and cracking.	Ventilation, Instrumentation and Control, Waste Preparation and Transfer (1.2 DST I&C, 1.3 DST Ventilation, 3.1 Mixer Pump, 4.0 DST Monitor and Control System)
		4. Tank 241-AZ-101 air lift circulation must be operable when waste solution temperature is >93°C (200 °F) and when sludge temperature is >110°C (230 °F). *Note: it is assumed that this will also be applicable to tank 241-AZ-102.*	BIO Addendum 1, Section 3.4.4. Required to avoid a steam bump. This requirement is currently only applicable to performance of the AZ-101 Mixer Pump Process Test. It is assumed that a similar requirement will be in place during waste feed delivery activities for both 241-AZ aging waste tanks.	Waste Preparation and Transfer, Instrumentation and Control, DST Utility Distribution System (1.1 DST Structure, 1.2 DST I&C, 4.0 DST Monitor and Control System, 5.1 Compressed Air)
	S2. Monitor for leaks or line misroutings	1. Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	TSR Control LCO 3.1.3 requires transfer system leak detection systems to be operable during a transfer. If the weight factor leak detection systems do not receive instrument air they will not function.	Utility Distribution, Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System, 5.1 Compressed Air)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
9. Transfer Solids Slurry from Tank	S1. Monitor for leaks or line misroutings	1. Perform material balance calculations during each waste transfer. Calculations shall be performed at 30 and 60 minutes following waste transfer initiation and every 2 hours thereafter until the transfer is complete (safety constraint)	HNF-SD-WM-TSR-006, 5.12.2.b. Timely detection of leaks or misroutings.	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitoring and Control System)
		2.Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	TSR Control LCO 3.1.3 requires transfer system leak detection systems to be operable during a transfer. If the weight factor leak detection systems do not receive instrument air they will not function.	Utility Distribution, Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System, 5.1 Compressed Air)
	S2. Prevent contamination of service water systems	1. Prevent backflow of waste from active waste transfer pump into service water systems that are physically connected during transfer	TSR Control LCO 3.1.2 requires that service water pressure detection systems be operable. Flushing system pressure switches and associated interlocks with waste transfer pumps or alarm response are used to stop inadvertent waste flow into flushing systems in transfer-associated structures that do not have covers. This prevents potential leaks from developing outside the transfer path. The pressure switches and associated interlocks or alarm response also prevent radioactive material from contaminating the service water supply system.	Waste Preparation and Transfer, Instrumentation and Control (1.2 DST I&C, 3.2 Chemical Addition System)
	S3. Detect subsurface leaks that remain subsurface	1. Transfer leak detection systems in systems and structures connected to a waste transfer pump and pipe-in-pipe encasements shall be operable	TSR Control LCO 3.1.3 requires transfer system leak detection systems to be operable during a transfer.	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)

Table 4-2. Safety Requirements Assessment for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Process step	Qualitative process safety objective	Quantitative Tank-Specific Process Safety Requirement	Safety Basis Reference	Affected Systems
	S4. Mitigate transfer spray leak	1. Ventilation stack CAM interlock systems shall be operable	TSR Control LCO 3.1.4 requires that ventilation stack CAMs and interlock systems be operable. The ventilation CAM interlock detects increasing radiological effluent release and stops the ventilation exhaust fan on DSTs, AWF tanks, and actively ventilated SSTs (C and SX tank farms) within 10 minutes. Stopping the exhaust fan protects against the continued unfiltered release of radioactive and toxic materials following the breach of the filter.	Instrumentation and Control (1.2 DST I&C, 4.0 DST Monitor and Control System)
10. Receive Solids Slurry into Tank	S1. Control tank waste temperature	1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top 4.6 m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6 m (15 ft).	HNF-SD-WM-TSR-006, Rev. 0, Section 3.3.2, Limiting Conditions for Operation, DST and AWF Tank Waste Temperature Controls, prevents tank bump or steam release event, protects against a postulated "chemical runaway" accident (Organic Salt-Nitrate Reaction)	Ventilation, Instrumentation and Control, Waste Preparation and Transfer (1.2 DST I&C, 1.3 DST Ventilation, 3.1 Mixer Pump, 4.0 DST Monitor and Control System)

5.0 WASTE PREPARATION AND TRANSFER SYSTEMS

The 241-AZ tank farm feed delivery system is graphically depicted in Figure 5-1. The waste transfer routes from 241-AZ-101 and 241-AZ-102 are depicted in red showing proposed routings through the new transfer lines and valve pits defined under Project W-314 and terminating at the HLW vendor interface. Diluent addition and primary exhaust routes are also depicted in Figure 5-1. Appropriate new mixer and transfer pumps to support process needs are shown in each 241-AZ tank. Current tank volumes and relative levels of sludge and supernate are also shown.

5.1 MIXER PUMPS

Properly designed mixer pumps will perform the following functions:

- Degas the waste. In some of the waste tanks hydrogen gas (which results from radiolytic processes) builds up in the sludge and crust layers and then is released in a gas release event. Controlled waste degassing prevents the release event from occurring during waste transfers.
- Mobilize and suspend/homogenize solids into the liquid thus allowing solid materials to be transferred and removed from a tank.
- Provide contact between soluble solids (salts) and the diluent liquid in the tank to aid in the dissolution process.

The alternative case in DeLozier (1998) identifies tanks 241-AZ-101 and 241-AZ-102 as being retrieved as HLW feed. Only one of the mixer pump functions (solids suspension) is required in these two tanks.. These two tanks will also serve as HLW feed staging tanks for additional HLW retrieved from other tanks. Although the M&I contractor team no longer is responsible for establishing sludge washing capability, the HLW feed must consist of relatively homogenous slurry transferred in batches as often as once monthly. Mixer pumps must be installed in both tanks which can homogeneously suspend the solids now present in the tanks as well as future HLW transferred to these HLW feed staging tanks.

5.1.1 Process Needs

The quantitative process needs which apply to the waste preparation and transfer system, including mixer pumps, are summarized as part of Table A-1. The mixer pumps are required to suspend the solids in tanks 241-AZ-101 and 241-AZ-102.

5.1.2 Existing and Planned Mixer Pumps

Project W-151 has installed two 224-kW (300-hp) mixer pumps into 241-AZ-101. These mixer pumps will be tested during fiscal year 1999.

5.1.3 Comparison of Existing and Planned Equipment to Expectations

Based on sludge mobilization testing (Powell et al. 1995), the mixer pumps are thought to be capable of mobilizing waste solids. It is important to note that a full scale test of a two mixer pump systems ability to mobilize sludge has not yet been performed. There are two mixer pumps located in tank 241-AZ-101, and a full scale test using this system is scheduled to occur in May or June 1999.

A potential issue with the mixer pumps is that the intake and outlet of the mixer pumps are located near the bottom of the pump. The sludge in at least some of the tanks is extremely viscous, and will resist pumping. It is not clear from the current design how the pumps are to be started either initially, or after a period of inactivity. If a sufficient amount of water cannot be added to the tank near the inlet of the mixer pumps, it will be very difficult or perhaps impossible to start the pumps without causing cavitation and potential failure of the mixer pumps. It may be necessary to redesign the mixer pumps such that the intake is located in the supernate and the discharge at the bottom to allow the mixer pumps to be started without cavitating. Ideally, the mixer pump design would include two or more intake heights which could be controlled such that the intake would remain in the liquid as the level in the tank were drawn down.

5.2 TRANSFER PUMPS AND PIPING AND VALVE ROUTINGS

5.2.1 Process Needs

Table H-1 of the TWRSO&UP (Kirkbride et al. 1997) identifies the projected transfers occurring in all tank farms through October 2011. The projected transfers are no longer fully consistent with the alternative case identified in DeLozier (1998). Both the previous set of transfers associated with sludge washing and the new set of transfers associated with DeLozier (1998) are identified in Table A-2. The set of transfers consistent with DeLozier (1998) will be examined as the set of transfers supporting waste feed delivery and all other relevant tank farm operations specific to 241-AZ.

241-AY & 241-AZ TANK FARM WASTE FEED DELIVERY SYSTEM

6/30/98

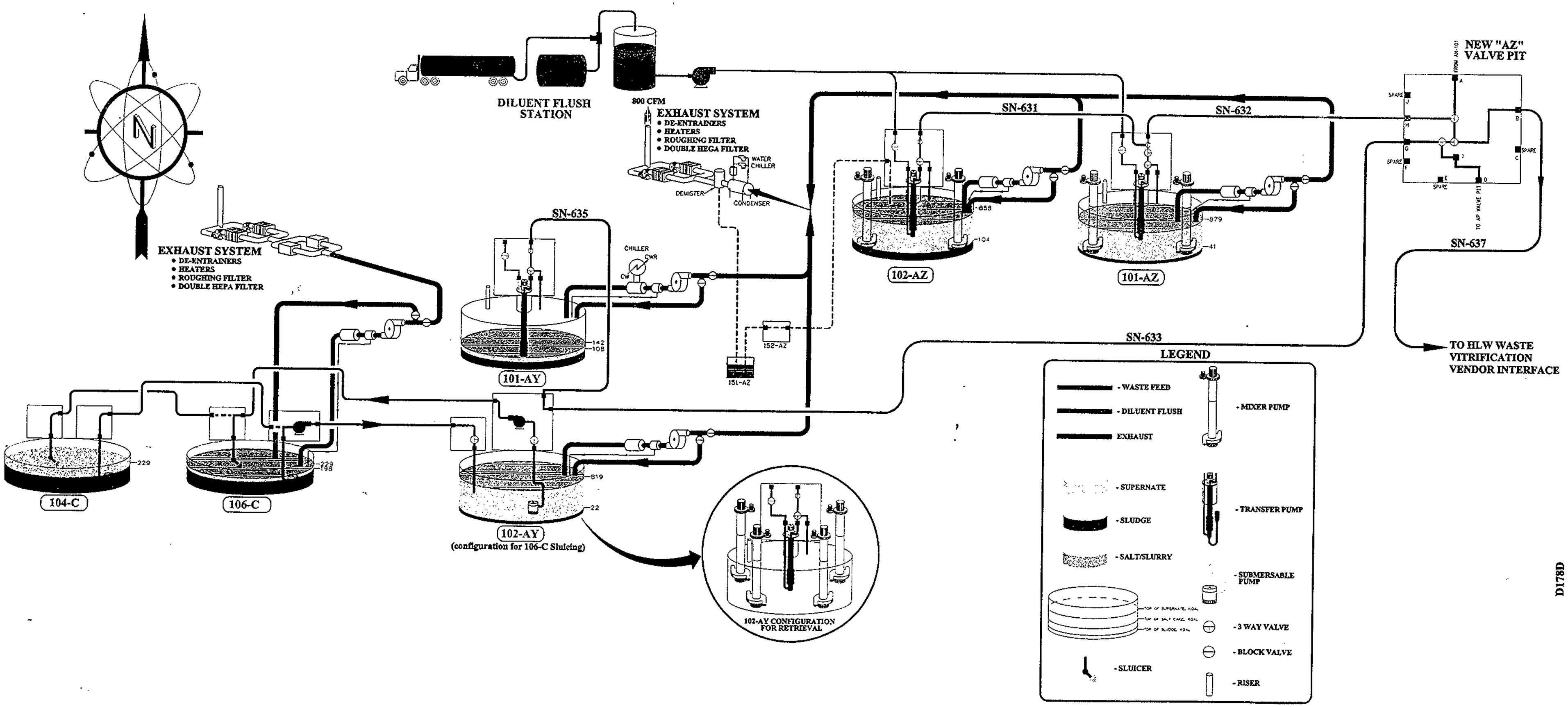

Figure 5-1. Tank Farms 241-AY and 241-AZ Waste Feed Delivery System.

D178D

5.2.2 Existing and Planned Transfer Pumps and Piping and Valve Routings

Table A-3 postulates a route for each transfer between tanks that is identified in Table A-2 consistent with DeLozier (1998). Table A-3 identifies whether all transfer equipment for tank to tank transfers either exists or is planned based on best available drawings, project documents, and other available information. Table A-3 is also used to compare the existing and planned transfer route equipment to the process needs. This comparison is discussed below.

5.2.3 Comparison of Existing and Planned Equipment to Process Needs

5.2.3.1 Comparison of Existing and Planned Piping and Valving Routings to Process Needs. Table A-3 provides a transfer equipment availability matrix identifying whether equipment is currently installed (and planned to remain installed rather than removed as part of an existing project) or whether the equipment is within the planned scope of a project.

5.2.3.2 Comparison of Existing and Planned Transfer Pumps to Process Needs. All planned transfers from 241-AZ tank farm are slurry transfers with up to 200 grams of unwashed solids per liter (DOE 1998). Table A-4 provides a transfer pump matrix identifying whether a transfer pump is currently installed (and planned to remain installed rather than removed as part of an existing project) or whether the necessary equipment is within the planned scope of a project. The type of pump planned for each transfer is also identified as well as the equivalent length of the transfer. The equivalent length of the transfer is used in determining the adequacy of the particular pump in meeting the process needs. The equivalent length is calculated by combining straight line length with length factors for various fittings and bends. Equivalent length and overall changes in height (hydraulic head) for portions of the various transfer routes is identified in Table A-5.

Of issue in the AZ tank farm is the current waste minimum in the tank. Both 241-AZ-101 and 102 currently have a minimum waste level of 1.6 m (64 in.) in the tanks as listed in OSD-T-151-00017. The annulus pump pits in each tank drain into tanks at a level of 1.63 m (64 in.) above the tank bottom. If the level in the tanks are drained to below 1.63 m (64 in.), the annulus ventilation system may draw contaminated vapor into the annulus pump pit, if the primary ventilation system is not operating but the annulus ventilation system is operating.

5.3 CHEMICAL ADDITION AND FLUSHING SYSTEMS

5.3.1 Process Needs

Liquids are added to the waste or to the transfer lines to dilute the waste, disolve soluable solids in the waste, adjust a characteristic of the waste such as pH, and to remove waste residuals from the transfer line. The liquids used consist of water with added caustic, nitrite, or nitrate compounds to inhibit corrosion or to adjust the waste characteristic. It is anticipated that most of the additions in tanks 241-AZ-101 and -102 will most likely consist of water flushes, which are used to remove residual waste from the transfer lines, will likely consist of dilute caustic and nitrite solutions. The dilute caustic and nitrite solutions are used to prevent corrosion of the transfer lines.

The diluent added to the tanks is introduced either at the transfer pump intake in the initial stages of waste retrieval from the tanks that are full, or directly to the tank once the tank level allows suficient volume to allow direct addition. The quantitative process needs associated with the additions of diluent or flush are presented in Appendix A, Table A-1.

5.3.2 Existing and Planned Chemical Addition and Flushing System

The current flush system is not capable of delivering dilution water or flush solution at the required rate of 530 L/min, and the new chemical addition and flushing system design for the 241-AN Tank Farm has not yet been completed. (Note: The 241-AN tank farm chemical addition and flushing system will be used for dilution and flushing in the 241-AZ Tank Farm consistent with Rieck 1998). For the purpose of this document it is assumed that the chemical addition and flushing system design for the 241-AZ Tank Farm will be functionally identical to the chemical addition and flushing system design for the 241-AP Tank Farm. The chemical addition and flushing system design for the 241-AP Tank Farm consists of a tank, heater(s), chemical metering pumps, and piping systems to deliver the flush/diluent. The system is designed to deliver up to 530 L/min of chemical adjusted (NaOH, NO_2, etc.) water at a temperature up to 66°C.

5.3.3 Comparison of Existing and Planned Equipment to Process Needs

With the assumption that the 241-AN Tank Farm dilution system design will be functionally identical to the 241-AP Tank Farm dilution system design, the system will be capable of meeting the process needs identified in Table A-1.

6.0 UTILITY DISTRIBUTION SYSTEMS

6.1 COMPRESSED/INSTRUMENT AIR SYSTEMS

The 241-AZ and 241-AY tank farms share a compressed/instrument air system which is located in the 701-A Building. It consists of two large capacity air compressors with a large capacity reservoir. Additionally, there are two emergency backups and generators. The system is capable of providing sufficient air to the Air Lift Circulators in the Aging Waste Facility (AWF). Therefore, any instrument air requirements will be easily met. This equipment is currently installed and can be verified as meeting the requirements for performing their safety significant functions.

The instrument air system supports the transfer systems into or out of the Aging Waste Facility. It provides instrument air to the weight factor leak detection system which are required to be operational per the Authorization Basis, technical safety reqirement (TSR) limiting condition for operation (LCO) 3.1.3, *Transfer Leak Detection Systems*. Normally redundant air source may be required; however, the weight factor leak detection system is backed up by portable conductivity probes.

The system also supplies air to an instrument enclosure (241-AZ-102A) and to various other instruments. Refer to Drawing H-2-68355, Sheets 1-7, *IEFD Tank Farm.*

6.2 RAW WATER SYSTEM

Raw water is supplied via a raw water line and trucks. Tanker trucks transport hot raw water used in 241-AZ tank farm. The raw water is then delivered to the transfer line or tank, via the tanker truck booster pump and some sort of jumper or connection to the transfer line. The use of "flush"jumper connections or other means will require additional steps by Operations to perform a flush after a transfer. Planned transfers routes from the 241-AZ tank farm may be as long as one mile. A one line volume flush would require approximately 30.3 m^3 (8,000 gal) of raw water. Tanker truckers typical capacity is in the range of 15 to 19 m^3 (4,000 to 5,000 gal). Therefore, two to three water trucks would be required to perform the flush. Performing flushes on a routine basis, i.e., two to three times a month and more, may be difficult for operations to support; therefore, additional equipment may be necessary to ease the operational burden.

The raw water system in 241-AN tank farm is planned to be upgraded by Project W-211 for 241-AZ-102 waste dilution and pipeline flushing (Rieck 1998). Although a specific interface point has not been chosen, a number of options exist (Rieck 1998).

6.3 ELECTRICAL DISTRIBUTION SYSTEM

The existing tank farms electrical supply may not be adequate to supply either the process need maximum load or the schedule based maximum electrical load. The process need load is more conservative than the postulated schedule load. The process need requires the independent operation of retrieval equipment in each of the four 200 East Area DST farms. This is equivalent to running two mixer pumps and one transfer pump in each farm, or, eight 224-kW (300-hp) mixer pumps and four 44-kW (60-hp) transfer pumps. The postulated schedule load is based on the integrated schedules. The integrated schedules show that at least once in each of the first three years of processing up to nine mixer pumps and one transfer pump may be needed simultaneously to suspend and transfer solids.

The substation installed by Project W-151 is fed from 13.8 KV line number C8-L6. The capacity of this line is approximately 7 MW and the existing average demand load is approximately 3 MW. The power requirement for a pair of 224-kW (300-hp) mixing pumps and a 44-kW (60-hp) transfer pump is about 640 KVA. The simultaneous operation of nine mixer pumps (one set of mixers in each of 241-AY-102 [four 112 kW (150 hp)], AZ Farm [two 224 kW (300 hp)] and AN [or AW] Farm [two 224 kW (300 hp)] and one [224-kW (300-hp)] mixer in AP Farm) cannot be achieved. Load flow and voltage drop analysis of 13.8 KV line C8-L6 indicates that the line cannot provide power to the postulated schedule maximum TWRS load of nine mixer pumps and one transfer pump operating simultaneously without experiencing excessive voltage drop in the tank farm area. The voltage drop will also be excessive for the process need requirement since it is more conservative than the postulated schedule load. To resolve this potential issue the possibility of transferring some tank farm loads to other electrical supply lines in the area (lines C8-L5 and C8-L8 are the most likely candidates) could be explored. Or, a more detailed examination of schedule constraints for simultaneous operation of nine mixer pumps could be examined and the process need for independent operation of each farm can be modified. The load flow study is summarized in Appendix F.3.1. A load projection study is also in progress to evaluate the changes in other loads on the distribution line in future years.

Project W-151 installed a substation that is adequately sized (1000 KVA) to support operation of a portion of the AZ retrieval system, although power availability will be limited to the concurrent operation of two mixer pumps and two transfer pumps for the combined AN farm and AZ farm retrieval systems. The AN system will allow for the flexibility of running one mixer pump in each of two tanks. If it is determined that simultaneous full speed mixing with two pumps is required in both tank farms or more than two mixer pumps must be operated in the 241-AZ tank farm (i.e., four mixer pumps total), then an upgrade of the existing substation would be required. In addition, the modifications being made by project W-211 will result in the existence of enough VFDs to operate four mixing pumps simultaneously, and, again, the existing transformer is only adequate to run two mixer pumps and two transfer pumps simultaneously. (However, it is uncertain at this time whether the 241-AZ tank farm ventilation system would be able to support the effects of heat input from more than two mixer pumps operating at full speed [Rieck 1998]).

Thus, in the event that more than two mixer pumps are required to be run simultaneously in AN farm and/or AZ farm, the substation will require upgrading, including replacement of the existing transformer with a larger one.

6.4 STEAM SYSTEM

No process needs for steam have been identified for 241-AZ tank farm. There is no steam in the aging waste complex.

These steam coils do not support any transfer system process needs. Therefore the steam coil non-operation is acceptable.

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7.0 INSTRUMENTATION, MONITORING, AND CONTROL SYSTEM

The mobilization, retrieval, transfer, pretreatment, staging, and delivery of feed to the private contractor takes place within the DST system. Operations within the existing DST system are controlled within the Basis of Interim Operation (BIO) authorization. Many of the in-tank processing steps associated with waste feed delivery will require new equipment and procedures for completion of the program objectives. These new operations must be monitored and controlled to stay within an approved authorization safety basis as well as to deliver waste feed within the constraints established by the Phase I privatization contract.

Successful waste retrieval and delivery of the proper composition waste feed to the private contractor within schedule requires that in-tank processing and transfers be effectively controlled. Development and implementation of a successful process monitoring and control system requires that overall process operational needs be clearly defined. These process needs consist of both objectives and constraints. Objectives are variables which are controlled around an optimal value whereas constraints are variables which must fall within certain bounds. Based on these control objectives and constraints, data requirements and variables to be monitored can be established. Plans can then be put in place to gather the needed data and/or provide monitoring instrumentation and control systems if existing systems are not adequate.

This section summarizes, develops, and documents the bases for a process monitoring and control strategy which will provide for the safe and successful delivery of HLW feed to the privatization contractor. The process monitoring and control strategy for each general process activity is developed separately. A list of expected monitoring instrumentation is developed for each process activity based on the control strategy. Each tank is then assessed individually to determine if existing and planned systems can successfully implement the monitoring and control strategy. As part of this assessment, expected instrument ranges, accuracies, and precision are developed. The basis for the process monitoring and control strategy is developed and documented in Appendix C of this document.

7.1 PROCESS MONITORING AND CONTROL STRATEGY

The following sections provide a proposed process control strategy for each of the applicable process steps described in Section 3. Descriptions of the equipment, the system requirements, the instrumentation requirements, and the system operation (startup, normal, and off-normal) are given for each process step.

7.1.1 Safe Storage

Tanks 241-AZ-101 and 241-AZ-102 are DSTs designed to provide aging waste storage space for high-level waste generated at the PUREX plant. To accommodate high-heat generating wastes, air lift circulators, steam coils, and exhaust condensers have been installed to minimize the probability of a loss of structural integrity.

The TWRS BIO requires that several systems and components used to monitor tank conditions be operable to prevent or mitigate certain analyzed accident scenarios. These BIO requirements provide much of the basis for the monitoring and control equipment needed to ensure safe storage of the existing inventory as well as material that will be transferred to the tanks as a part of future waste transfers. The current BIOS controls are used as the basis for determining what will probably be minimum requirements. It is noted here that further Authorization Bases (AB) requirements may be forthcoming.

7.1.1.1 Description of Primary Equipment. The primary equipment used to safely store waste (other than the inner and outer tanks and supporting structures) include the following.

a. Active ventilation system. Equipment includes high-efficiency particulate air (HEPA)-filtered air inlets to the primary tank (with vacuum breakers), annulus air inlets, a recirculation system for cooling, tank pressure controls, variable speed fans, and a common annulus exhaust with HEPA filtration.

b. Air lift circulators. Each tank has 21 air lift circulators installed. These circulators are long, open-ended cylinders of varying lengths immersed in the tanks' contents. Compressed air from the instrument air discharges into the air circulator and exits at the base of each cylinder causes a flow of waste from the bottom to the top of the tank, thus mixing the contents.

c. Service water system. Filtered, raw water from the site water system is available for priming, pump seals, and flushing for mixer and transfer pump operations and can also be used to maintain waste temperature within requirements. The BIO does not take credit for the availability of mixer pumps during storage, but relies on the air lift circulators for the removal of "hot spots" in the stored waste.

7.1.1.2 Description of Instrumentation. The instrumentation needed for monitoring and control to ensure that wastes are stored safely are divided into two categories in the following discussion. The measuring and control equipment (instrumentation) needed was determined by evaluating the process step (safe storage) in more detail to establish needs and requirements based on process needs (Table C-1), safety requirements (Table C-2) and postulated off-normal operational occurrences (Table C-3). The resulting process parameters to be controlled are captured from all three of the foregoing tables in Table C-4 in which the expected monitoring and control approach is specified. The approach is, for the most part, at this point independent of existing or planned instrumentation. The following discussion explains the rationale for the selected monitoring and control approach in Table C-4.

Primary Equipment Instrumentation

a. Active ventilation system. Instrumentation is needed to measure exhaust stack air flow rate, presence of radiation in the exhaust stack, and differential pressure across the inlet and exhaust HEPA filters for both the primary tank and annulus ventilation systems. Refer to Section 7.0 for details.

   Exhaust stack air flow rate: The active ventilation system is required to be operable at all times. Measurement and display of air flow rate will provide the indication that the ventilation system is operable. Using an isokinetic air sampler is recommended since the sampler is needed for radiation monitoring [continuous air monitor CAM system] and air flow rate is available from the same system.

   Exhaust stack radiation: A continuous air monitor (CAM) to detect beta and gamma radiation is required by the BIO. Presence of high radiation must also be interlocked to trip the ventilation fan to preclude the release of contamination. The CAM will alert the operator that HEPA filters have been breached due to aerosol saturation, high temperature (fire) or breakthrough (low differential pressure). Radiation values need to be indicated, recorded, and alarm (hi) at greater than 10,000 cpm. (BIO TSR LCO 3.1.4)

   HEPA filter differential pressure: High differential pressure is an indication that the filter needs to be replaced before its capabilities degrade to the point of failure. High differential pressure can be easily monitored with a differential pressure transmitter, with displays locally and in a central control area.

b. Air lift circulators: Instrumentation is needed to measure instrument air supply pressure and flow rates. The air lift circulators are required to be operable in 241-AZ-101 when the average waste solution temperature is greater that 88°C (190°F). and when the sludge temperature is greater than 110°C (230°F). To prevent excessive temperature gradients which in turn could lead to the release of radioactive gases due to excessive boil-off rates (bumps). Pressure and flow transmitters are needed to provide indication of pressure and flow values and provide alarms for low pressure and low flow. No interlocks are required since operator action will be required to re-establish the air supply. To satisfy LCO 3.3.4, when the air supply is inoperable, mixer pump operation must stop, cover blocks must be in place, the primary tank ventilation system must be operating, and the circulators must be returned to operable status within 20 hours.

c. Service water system. The service water system supplies filtered raw water and raw water with added inhibitors for use as tank waste diluent; mixer and transfer pump initial column fill, seals, flushing, and decontamination; transfer piping flushing; and slurry transfer diluent. The system can also be used for tank waste temperature control during the "safe storage" process step along with mixer pump needs if the latter is used to keep temperature gradients within limits. Instrumentation needed for the service water system includes pressure indication and alarms to determine system operability and a water flow totalizer (TSR AC 5.21) to preclude overfilling of the primary tank. The latter will be used in conjunction with primary tank level readings.

Tank Specific Instrumentation

a. Primary tank: The following instrumentation is needed to monitor and control parameters required to maintain the tank's integrity and to mitigate flammable gas and tank "bump" concerns regarding the waste.

Vapor space pressure. The air space between the top of the waste and the tank's dome must be monitored for pressure. The pressure must remain negative, i.e., <0 m (0 in.) of water (vacuum), *(Ref: TSR Bases B 3.2.1)*. Vapor space pressure is the primary indication of proper operation of the active ventilation system (TSR Bases B 3.2.1). An absolute pressure transmitter with remote indication, high and low alarms, and a recorder (to record trends) are needed to instrument vapor space pressure.

Hydrogen gas monitoring system. The 241-AZ tanks are classified as Facility Group 2 which means that they are subject to large induced gas release events (GRE) but a small spontaneous GRE. This means that operations such as mixing that disturb the waste (induced GRE) have the potential to release quantities of flammable gas into the vapor space that would exceed 25 percent of the lower flammability limit (LFL). Also, the effects of a spontaneous GRE (undisturbed waste) would not be sufficient to cause the vapor space to see greater than 25 percent of the lower flammability limit (Ref. TSR AC 5.9). Although several flammable gases could be released, analysis shows that a limit of 7500 ppmv of hydrogen accommodates concentrations of mixtures of flammable gases (BIO 5.3.2.14).
A hydrogen monitoring system that withdraws samples from the tank vapor space is needed with hydrogen concentrations verified by sampling at least once each 72 hour period. (Ref. TSR LCO 3.2.1) A continuous sampler is recommended to better establish trends. Hydrogen concentrations need to be indicated, recorded (with trending capability), and alarmed when they exceed 7500 ppmv.

Waste temperature. The BIO limits waste temperatures to less than 91°C (195°F) in all levels of the waste OR to less than 91°C (195°F) in the top 4.6 m (15 ft) of the waste and less than 102°C (215°F) in the waste below 4.6 m (15 ft). This requires temperature detection at various levels within the waste. Under static conditions, temperature should be measured at the supernate layer, in the sludge layer, and at the air lift circulators (when they are in operation). Additional measuring locations will be needed for process steps of mixing tank waste and transferring waste from the tank. Temperature monitoring of the waste includes obtaining, transmitting, receiving, recording, and displaying temperature values with alarms set so as not to exceed the LCO limits. The required accuracy is ± 0.6°C (1°F) according to WHC-SD-W314-ES-007 (Trade Study for Tank Waste Temperature). The expected accuracy using thermocouples would be about ± 1.6°C (2.8 °F). In order to obtain the required accuracy, resistance temperature detectors (RTDs) are needed to obtain the temperature values.

Primary tank level monitoring. During the safe storage process step, waste level in the primary tank is required, in conjunction with primary tank leak detection and waste temperature, to prevent subsurface release of radioactive materials due to leaks in multiple tanks (TSR AC 5.21). Tank level is also required to prevent overfilling of the tank and to prevent uplifting of the bottom (insufficient heel). The level of tank contents needs to be through direct means to ensure that an accurate value is obtained that is independent of layering in the tank and the condition of the interior tank wall. The recommended approach is to use a float attached to a sensing system in a riser, similar to ENRAF™ equipment used for chemical storage tanks. The level values need to be indicated (displayed), recorded, and alarms set at 1.6 m (64 in.) (lo), 9.25 m (364 in.) (hi), and 9.40 m (370 in.) (hi-hi, safety limit). High alarm needs to be interlocked to shutdown diluent addition while the low alarm is interlocked to shutdown an operable transfer pump.

b. Secondary tank: The following instrumentation is needed to monitor and control parameters required to detect leaks from the primary tank, transfer line mis-routings, and to maintain temperatures within limits that maintain primary and secondary tank structural integrity.

Annulus liquid level. Any waste leakage from the primary tank will be collected in the annulus where it is channeled to the outside of the secondary tank. Leak detector (conductivity) probes are needed to detect a liquid leak and must be set within 2.54 cm (1 in.) of the bottom of the annulus (TSR LCO 3.2.6). At least one probe must be operable at all times. The presence of a liquid is conveyed to the operator via audible and visible alarms.

Radiation level. The second method of leak detection is the monitoring the annular space for gamma radiation. Radiation is monitored using a CAM that obtains a sample of the annulus ventilation exhaust downstream of the HEPA filters. The CAM provides indication over a range of 0 to 10,000 dps with a high radiation alarm set at 4,000 dps (WHC-SD-W314-ES-008, Trade Study for Leak Detection). The high alarm is interlocked to shut down the annulus ventilation fan.

7.1.1.3 Description of Other Support Systems. Not applicable to this process step.

7.1.1.4 Description of System Operation. See Section 7.1.1.2 above. Degassing the waste is not applicable to 241-AZ tanks.

7.1.2 Process Step: Degas Feed

Degassing the waste is not applicable to 241-AZ tanks.

7.1.3 Process Step: Settle Solids

Settling solids is not applicable to 241-AZ tanks.

7.1.4 Process Step: Dissolve Solids

Disolving solids is not applicable to 241-AZ tanks..

7.1.5 PROCESS STEP: MOBILIZE AND SUSPEND SOLIDS

The purpose of the mixer pump is to mobilize greater than 90 percent of solids initially in 241-AZ-101 and greater than 60 percent of the solids initially in 241-AZ-102. In addition, these mixer pumps will be capable of mixing greater than 99 percent of solids transferred from tank 241-AY-102.

7.1.5.1 Description of Equipment. Two Mixer pumps will be installed in tank 241-AZ-101 and 241-AZ-102. Each pump will be capable of rotating between 0-180° such that the discharge nozzles can be aimed in any radial direction in the tank. The Diluent system will be a skid mounted system consisting of caustic metering pumps, caustic supply truck bay, eye wash down center, caustic storage tank heating system, and encased pipes for caustic delivery to the 241-AZ tanks. Table C-5 tabulates the monitoring and control instrumentation parameters needed in support of Phase 1 delivery. Table C-6 tabulates the monitoring and control equipment available for 241-AZ tank farm in support of Phase 1 feed delivery. Table C-7 summarizes the basis for adequacy of the existing equipment and any comments.

7.1.5.2 Description of Instrumentation

7.1.5.2.1 Mixer Pump Instrumentation. Each mixer pump is instrumented to provide the following monitoring and control capability. In addition, each mixer pump will have safety interlocks integrated in the controls to ensure tank integrity at all times.

Each Mixer pump will have following instrumentation:

a. Speed Control- Variable frequency drive to adjust mixer pump speed from 58 percent to 100 percent of full speed.

b. Motor winding temperature - to indicate pump motor temperature.

c. Motor Bearing temperature- to indicate pump bearings temperature.

d. Motor Current: -to indicate pump current usage.

e. Nozzle Position Indication- To provide indication of mixer nozzle position orientation.

7.1.5.2.2 Instrumentation Specific to the Tank.

aa. Tank Temperature - To monitor tank temperature at various levels and locations to provide temperature gradient and differential temperature information.

ab. Tank Dome Pressure- to monitor tank pressure.

ac. Tank Content Consistency- To verify liquid and sludge in the tank has been mixed uniformly over the length of the liquid level.

ad. Tank Level- to provide tank level indication.

ae. Radiation Monitoring- To monitor radiation level changes during mixer operation.

7.1.5.2.3 Diluent Systems Instrument Description. Diluent system - Provide diluent in the tank for flushing or reducing the solid content of waste for transfer. The diluent system is a major system and must meet the following meet the following requirements:

- Diluent liquid will have pH and conductivity controlled to meet specific parameters which are to be determined.

- Diluent system will provide liquid at 5.8 kPa (70 psig) pressure at mixer pump intake.

- Diluent liquid will contain solids less than 30 wt%.

- Diluent system will have the capacity to dilute the waste such that a minimum velocity of 1.2 m/sec can be achieved.

- Transfer system will be designed such that it will not exceed operating pressures and maintain the minimum critical settling velocity of >1.2 m/sec (4 ft/sec).

- Diluent system monitoring and controls will use state of the art PC based system for data transmission and trending .

The Diluent system will have the following instrumentation .

- pH monitoring and/or Conductivity Monitoring - to ensure diluent liquid meets corrosion specification.

- Pressure Monitoring at tank inlet.

- Flow Totalizer (Non Resettable).

- Caustic temperature monitoring.

7.1.5.2.4 Description of Other Support Systems.

1. Service Water System- To provide water for mechanical seals, initial column fill prior to mixer pump operation, and for sparge ring operation.

2. Tank HVAC system- To maintain tank dome at negative pressure.

3. Tank Imaging System- To monitor internal tank operations or component integrity.

4. Air Lift Circulation System- To maintain sludge temperature below 110 °C (230 °F) and waste temperature below 88 °C (190 °F).

7.1.5.3 Description of System Operation.

7.1.5.3.1 Mixer Pump Operation.

Startup

Mixer pump(s) can be operated at any time provided sufficient net positive suction head (NPSH) is available or per an approved operating procedure. If the transfer pump is operating, mixer pump(s) speed may be automatically reduced.

Prior to startup of mixer pump, liquid will be measured by ENRAF™ instrument. To protect the ENRAF™, the float will be retracted out of liquid and locked in safe position (below High- Level alarm).

On the initial startup of the mixer pump(s), or after any prolong ideal period when intakes may be immersed in a layer of sludge, flush water or diluent will be added in the mixer pump suction area to dislodge any sludge to avoid motor over current trip or locked rotor trip. Service water may be added to the mechanical seals to ensure seal life and allow proper seal operation and to the sparge rings to flush the nozzle

Mixer pumps will be started from the VFD control panel. The mixer pump speed should be controlled by a programmable logic controller (PLC). During mixer pump operation, the following parameters will be monitored at various locations.

AT VFD PANEL

- Motor Current and Voltage
- Motor Winding Temperature
- Motor Bearing Temperature
- Motor Speed

AT PLC and TMACS

- Liquid and Sludge Temperature from thermocouple tree (MIT)
- Tank Dome Pressure
- Tank Dome Radiation Level
- Liquid/Solids sludge level monitoring
- Motor current, winding temperature, motor bearing temperature, motor speed, and motor/pump vibration
- System alarms monitoring.

Normal Operation

Mixer pump speed will be controlled by a PLC. The PLC based control will have an industrial PC with Pentium™ processor with visual monitoring and control capability. Visual monitoring will be in the graphic format to assist an operator to get an information instantly by depressing a function key. The graphic screen displays will be arranged as follows:

1. Overall system configuration showing mixer pump, nozzles, mixer pump status-On/OFF, etc.

2. Mixer pump screen display will have:
   Motor status -ON/OFF lights
   AUTO/REMOTE/LOCAL switch
   Motor current
   Winding temperature
   Bearing temperature
   Vibration indication and alarm indication
   Nozzle position indication
   Service water pressure and flow.

Mixer pump speed will be increased in steps until the desired pump operating speed is obtained. The MIT temperatures will be monitored for readings that indicate a 5.6 °C (10 °F)/hr change or a maximum heat up rate limit of 11°C (20 °F)/day will be exceeded. In addition temperature will be monitored to ensure that temperature gradient does not exceed 100°C/m (55°F/ft) within the solution or at the waste liquid/vapor interface. If any of these limits are approached, mixer pump operation may be modified accordingly or other corrective action may be taken, e.g., operation of air lift circulators. The ramp up rate and the temperature monitoring frequencies need to be developed.

Once temperatures are within allowable limits, speed will be increased and mixing will continue until temperature readings on the MIT over the entire length show uniform temperature. The required tolerance on the temperature readings is to be determined. Mixer pump operation may be stopped for tank level monitoring by the ENRAF™. In addition, during mixer pump operation, the tank imaging system may be used as well as the ultrasonic interface level analyzer (URSILLA). The tank imaging system may be required for various purposes, e.g, visual observations of components, tank level changes, etc. The URSILLA will be used to detect a liquid/solids interface for a determination of mixing effectiveness.

Off Normal

Mixer pump operation will automatically stop on the following events:

- Electrical power failure.

- Loss of mechanical system integrity, e.g. pipe break, ALC failure, etc.
- Seismic Event.
- Emergency STOP (Manual operator action).

7.1.5.3.2 Diluent System Operation. The purpose of diluent addition is to dissolve solids, provide flush water, prevent pump cavitation, and to maintain waste temperature within allowable limits. Diluent will be added to the tank in the last two transfers to be made to the privatization contractor.

Diluent will be added to the tank at a predetermined tank level which yet to be determined within a tolerance which is also yet to be determined or where pump cavitation begins . Prior to addition, diluent will be analyzed to verify that pH is at an appropriate level. Diluent will then be added to the tank by opening/closing of appropriate valves. Flow totalizer in diluent discharge line and tank level will be monitored. When flow totalizer indicates 379 m^3 (100,000 gal), diluent addition will cease. Concurrently the waste temperatures from the MIT will be monitored. The mixer pump may be in operation during this process or may not operate until the diluent addition is complete.

If diluent addition terminates due to manual operator action or equipment /component failure, diluent flow totalizer will not be reset until it reads 379 m^3 (100,000 gal).

7.1.6 Process Step: Sample Waste

The waste contained within 241-AZ-101 and 241-AZ-102 needs to be characterized before it is transferred to the privatization contractor. Characterization will be done by analyzing samples of the waste for chemical constituents, pH, density, viscosity, and other parameters in accordance with existing Data Quality Objectives (DQO). Representative samples (200 grams of solids) will be provided to the privatization contractor at least 30 days prior to the first transfer of the waste to the contractor's feed tank. These samples will be used to ensure compatibility between the sending and receiving tank inventories and to confirm that waste composition is within contract specifications.

7.1.6.1 Description of Primary Equipment. The waste sampling system needs to have the following capabilities:

a. Obtain grab samples from any level within the waste

b. Obtain multiple samples from the same location

c. Be able to handle waste of varying specific gravities (1.0 to 1.5) and densities

d. Transfer samples to a shielded container for transport to an analysis facility

e. Be easily and reliably decontaminated and cleaned so that multiple samples remain truly representative of the in situ waste

In addition, the waste sample must be extracted through an existing riser keeping radiation and contamination as low as reasonably achieveable (ALARA). Sample labeling must be provided to satisfy chain of custody and traceability requirements.

7.1.6.2 Description of Instrumentation. No permanent instrumentation is required in addition to that specified in 7.1.6.1. Radiation can be ascertained using portable equipment. Analytical instrumentation will be provided by the laboratory doing the required analyses and will be dependent on the characteristics of interest. Parameters which may considered include density, viscosity, percent entrained solids, concentration of sodium, pH, etc.

7.1.6.3 Description of Other Support Systems. Potentially, support systems that could be needed include dry air or nitrogen (see in-tank camera discussion in Section 7.1.5) and service water for flushing or decontamination.

7.1.7 Transfer Liquid from Tank

Transfer of liquids from tanks is not applicable to 241-AZ tanks.

7.1.8 Receive Liquid into Tank

Receipt of liquids into tanks is not applicable to 241-AZ tanks.

7.1.9 Transfer Solids Slurry from Tank

The purpose of the Solids Slurry Transfer system is to transfer the solids slurry to the privatized vendor for processing. Solids slurry transfer system will be operated once the 241 AZ tank contents are properly mixed .

7.1.9.1 Description of Primary Equipment. Slurry transfer system consists of Slurry transfer pump(s) and above ground (properly shielded) encased transfer line.

7.1.9.2 Description of Instrumentation. Slurry transfer line will be instrumented to provide following monitoring and control utilizing state of the art PC based system. In addition, it will have an automatic interlock from other dependent systems to ensure that transfer operation will not jeopardize the equipment and personnel safety, as well as will not create an environmental hazards.

7.1.9.2.1 Transfer Line Instrumentation.

- Transfer line pump discharge pressure monitoring and Low and High pressure alarms and trip.
- Flow monitoring and totalizer (Non Resettable automatically).
- Leak detection monitoring system at 305-m (1,000 ft) spacing, and at either end of pipe, with automatic trip function.
- Transfer line pressure monitoring along the length of pipe to monitor evidence of Settling of solids (pipe plug).

7.1.9.2.2 Transfer Pump Instrumentation

- Speed Control-VFD to adjust pump speed from 58 percent to 100 percent of speed.
- Motor winding temperature- to provide motor winding temperature information.
- Motor Bearing Temperature- to provide bearings temperature information.
- Motor Current and Voltage- to control pump speed.
- Motor Vibration- to indicate occurrence of cavitation.

7.1.9.2.3 Other instrumentation required for slurry transfer

- Tank level monitoring-to indicate and provide trip function.

7.1.9.3 Description of System Operation. Solids slurry from tanks will be transferred to privatization contractor by an encased above ground pipe. This pipe will have berm around it to reduce radiation dose to the workers in the vicinity, and its size will be based upon the velocity of transfer which will ensure that, once the transfer is initiated, it will not accumulate solids on the pipe walls.

Slurry transfer will be done in 379 to 1140 m^3 (100,000 to 300,000 gal) batch and will be terminated, in normal operation, when the tank level reaches mixer pump inlet.

7.1.9.4 Other systems required to be operational during slurry transfer.

- Diluent/flush system - to provide enough diluent volume to flush transfer lines after transfer is completed or when the pump trips due to protective interlock actuation.

7.1.9.5 Slurry Transfer System Description. Slurry Transfer System will have the following operational modes.

7.1.9.5.1 Ready Mode. In this mode, all pump status, valve status, system instrumentation- pressure, flow, leak detection, tank level, will be displayed. Automatic system operation may be required. In addition, mixer pump and dilution system status will also be displayed.

7.1.9.5.2 Dilution/Flush Mode. In this mode, dilution system will be checked for its readiness to supply enough quantity of diluent/flush liquid at required discharge pressure and volume.

7.1.9.5.3 In Tank Recirculation Mode. In this mode the transfer pump will be started and the liquid will be recirculated back to the tank. During this operation pump operation may be adjusted to optimizing waste transfer to the privatization contractor.

7.1.9.5.4 Transfer Mode. In this mode, the transfer will be initiated to the privatization contractor. During this mode, transfer operation, transfer line, and tank level parameters are monitored. When flow totalizer indicates total volume transferred is equal to a set point, transfer to the privatized contractor will be stopped. At this point the transfer pump discharge may be automatically recirculated for a period of time before a trip or stop action occurs. When the transfer operation is stopped, flushing may be initiated to flush the transfer line. In addition, transfer operations may be interrupted by a transfer line leak detection system trip, transfer pump motor trip, power loss, or other events. The flush of the transfer system may also occur for these events. At the end of flush operation, flow totalizer reading will be taken to correlate the volume transfer with privatized contractor tank volume data.

7.1.10 Process Step: Receive Solids Slurry Into Tank

As a part of inter-tank waste transfers, 241-AZ-101 and 241-AZ-102 will receive waste from other storage tanks for interim storage and treatment prior to transfer to the privatization contractor. The major instrumentation need during the transfer itself is to ensure that the receiver tank (241-AZ-101 or 241-AZ-102) is not overfilled. Other process steps apply to this situation once the waste is received, specifically safe storage (7.1.1), add diluent to tank (7.1.5), mix tank contents (7.1.5), and sample waste (7.1.6). This process step, receiving solids slurry into tank, contains no additional monitoring and control equipment beyond that described in the above sections.

7.1.10.1 Description of Primary Equipment. The primary equipment needed for this process step are the tanks and connected piping, pits, diversion boxes, and a drop leg on the fill line (or other method of discharging liquid below the tank waste surface) to minimize generation of aerosols.

7.1.10.2 Description of Instrumentation. The only instrumentation pertaining directly to this process step is that necessary to monitor the level of waste in the tanks. This instrumentation, described in detail in Section 7.1.1.2, should be a float attached to a sensing system in a riser (ENRAF™ system). The level values need to be displayed, recorded, and alarms set at 9.25 m (364 in) (hi), and 9.40 m (370 in) (hi-hi, safety limit). High alarm can be used by the operator to terminate the waste transfer and to shut down any diluent addition.

7.2 SUMMARY OF PROCESS MONITORING AND CONTROL ISSUES

Issues specific to instrumentation, monitoring and control are summarized in Table 2-2. These issues were developed only for existing equipment and planned equipment where project scope is definite and definitive design is proceeding. Additional issues may arise as project designs mature.

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8.0 VENTILATION SYSTEM

8.1 PROCESS NEEDS

The quantitative process needs in Table 4-1 and the safety-related requirements in Table 4-2 of this document which apply to the ventilation system are summarized in Appendix D. The primary ventilation system must remove heat, air, evaporated water and evolved gases from the primary tank. The annulus ventilation system must remove heat and moisture and sweep the annular space to radiation detectors.

8.2 EXISTING AND PLANNED EQUIPMENT

The original AWF primary ventilation system was replaced by a new ventilation system (241-AZ-702) provided by Project 702-AZ (W-030). The primary tank ventilation system contains individual controlled air inlets and a common ventilation off-gas exhaust for the four AY and AZ Tank Farm waste tanks (241-AY-101, 241-AY-102, 241-AZ-101, and 241-AZ-102). The individual tank air inlet consists of a heater, pre-filter, HEPA filter, flow control valve. A recirculation ventilation cooling system is provided for each waste tank to help reduce emissions and remove heat generated in the tanks. The cooling equipment includes a condenser, moisture separator and recirculation fan for each system. Heat is rejected the recirculation condenser cooling system which consists of an evaporative fluid cooler, two circulation pumps, an expansion tank, an air separator, and instruments for monitoring the closed loop cooling system.. Each tank is manifolded into a common exhaust stream. The combined exhaust stream from all four tanks flows through a condenser and then through a high-efficiency mist eliminator (HEME) to eliminate any water droplet carry over into the filter system. Upon exiting the HEME, the gas stream is heated by electric heaters to protect the downstream HEPA and HEGA filter banks. Each bank consists of two HEPA filters and a High-Efficiency Gas Absorber (HEGA). The ventilation gas stream, after passing through one of the two filter banks, is exhausted by one of two exhaust fans up the exhaust stack to the atmosphere. One fan is in standby while the operating fan maintains a vacuum on the four storage tank vapor spaces.

The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational and leak detection for the primary tank is provided by conductivity probes in the tank annulus. Next year plant maintenance plans to restore the system to operation under its original configuration (one for one replacement of failed components). It is not known at this time if the Project W-151 mixer pump tests will require a functional annulus exhaust system or if the system will be functional to support the testing.

8.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

8.3.1 Primary Ventilation Exhaust Fan

Suspension of solids within the Aging Waste Facility tanks is provided by operation of mixer pumps. The mixer pumps generate heat which in turn increases water and particulate generation. The ventilation system must be adequately sized to accommodate the tank mixing operations during Phase 1 privatization feed delivery by removing heat, particulate, and water while maintaining vacuum within the tank headspace. Table D-1 identifies that the existing primary ventilation exhaust fan is not adequate to provide the necessary level of vacuum and too much air in leakage is occurring into the Aging Waste Facility tanks to allow control of the ventilation flows through each tank.

8.3.2 Primary Ventilation System Filter Train

During operation of the 241-AZ-702 (W-030 upgraded) system, there have been two instances where the filter plenum housings have had moisture collection problems. When the system initially started up the sealpot drain line tie in at 241-151-AX catch tank was blocked and liquid flooded the sealpot and backed up into the filter plenum housings. The next time moisture collected in the filter plenum housings the condenser and HEME in the 702-AZ building were operated in a by-pass mode and after 4 days approximately 132 L (35 gal) had accumulated in the housing. The operations engineers stated there was no time for planned outages of the condenser and HEME because of the flooding problem and a redundant system (condenser and HEME or just HEME) would be desired.

The primary ventilation system HEPA and HEGA filter plenums are not in compliance with ANSI N509, Section 5.6.2. "The drain system shall be designed so that no unacceptable backup of liquids into the housing will occur" and "Each housing compartment shall have floor drains which meet all allowable air leakage criteria." Both filter housings should have drain capability added for all compartments.

8.3.3 Equipment Installation and Removal from Aging Waste Facility Tanks

Equipment (thermocouple tree, transfer pumps and mixing pumps) will require installation or removal from the DST which will create openings in the DST dome to atmosphere during this operation. To insure the containment of the DST vapors, a negative pressure in the tank dome needs to be maintained. The largest riser in the DST dome is 1.07 m (42 in.) in diameter which has an area of 0.89 m^2 (9.6 ft^2) open to the atmosphere. The existing ventilation system may not have enough capacity to insure that the tank dome can be maintained at a negative pressure and perform all its other functions for the other three tanks in the system.

8.3.4 Slurry Distribution

An evaluation was performed (Kriskovich 1998 Draft) stating higher radiation in the re-circulation module was occurring due to aerosol/moisture settling out in piping, ductwork and equipment. The report concluded in order to reduce the radiation buildup in the re-circulation modules a dropleg or some other method of transferring directly into the tank contents is recommended over the current practice of using a slurry distributor.

8.3.5 Annulus Ventilation System

The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational. It is not known at this time if the mixer pump operation will require a functional annulus exhaust system or if the system will be functional to support mixer pump operation.

8.3.6 Air In Leakage and Vacuum Control

The primary tank air inlet stations are not now in operation and are valved shut. The inlet air is from air lift circulation (if operating) and outside air drawn into the tank through pit cover blocks, risers or uncapped transfer lines that are open to other sources such as the 241-AX-152 diverter station. Air in leakage and vacuum level can not be well controlled under the existing configuration.

8.3.7 Thermal Analysis of Tank 241-AZ-101 Waste Removal

A preliminary thermal analysis (Appendix E-1) of tank temperature rise with mixer pump operation in tank 241-AZ-101 predicts a temperature increase of 17°C (31°F) after 138 hours of operation associated with the first transfer of slurry to the private contractor. This preliminary calculation does not account for temperature profiles within the non-convective layer of solids at the bottom of the tank. Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the temperature increase calculated in the preliminary calculations).

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9.0 SAMPLING SYSTEM

Waste sampling activities in the 241-AZ tank farm will be required prior to transfer to the BNFL facility. The need for sampling before a waste transfer is required per the BNFL Interface Control Document (ICD) (BNFL 1998). All tanks in the 241-AZ tank farm have adequate numbers of free risers to allow sample taking. The ICD allows the use of grab sampling or core sampling. As a precondition of sampling the mixer pumps are to be run to mobilize the tank waste.

The use of grab sampling and or core sampling will be established for each tank waste based on the characteristics and capability of the sampling systems. Per the ICD:

> "Immediately following the shutdown of the mixer pump, approximately equal volume grab samples of waste material will be obtained from every two feet of waste height from below a single riser for a grab sampling technique. (For a core sampling technique a core the (sic) entire height of the tank waste will be obtained.) The total sample volume, will meet the sample volume needs for: analysis of the tank waste to support feed certification, a sample to BNFL, and archive sample material. The tank waster sample provided to BNFL will contain at least 200 grams of solids. Tank waste conditions such as temperature and tank volume will be identified at the time of sampling. Tank sample material will be stored in archive until treatment service has been completed and the IHLW waste products have been accepted by DOE."

In addition there are several other additional requirements that must be satisfied including:

- Prepare a composite Tank Waste Sample.
- Analyze Sub-samples to verify Composition; at least 3 sub samples of the composite sample will be used for feed certification analysis.
- Certify Tank composition and inventory the feed by combining information on the tank volume and tank waste composition.
    - Volume to be measured by use of the ENRAF 854 ATG level detector
    - Tank waste composition to be reported to an accuracy as stated in section 4.3.4 I the ICD.
- Provide certification that tank waste meets the requirements of section 8 of the ICD.

It is noted here that the grab sampling and the core sampling systems and procedures are well developed. However, it is not known at this time where the waste will be certified. In addition the time requirement to have a sample certification complete, i.e., less than 30 days is a major issue.

10.0 REFERENCES

BNFL, 1998, TWRS-P Project Interface Control Document, BNFL-5293-ID-20, Rev. 2, BNFL, Inc., Richland, Washington.

Claghorn, R. D., I. G. Papp, and B. B. Peters, 1998, *Performance Requirements for Phase 1 Waste Feed Delivery Components*, HNF-1985, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

DeLozier, M. P., 1998, *Subcontract number 80232764-9-K001, Evaluation of Tank Waste Disposal Alternatives Within Privatization*, Letter LMHC-9854671A R1, to A. M. Umek, FDH, (June 15), Lockheed Martin Hanford Corporation, Richland, Washington.

DOE, 1998, *BNFL Inc., TWRS Privatization Contract Number DE-RP06-96RL13308*, U.S. Department of Energy, Richland, Washington.

Grams, W. H., W. L. Cowley, and K. H. Morris, 1997, *Authorization Basis Assessment of Waste Feed Delivery*, HNF-1948, Rev. 0, Duke Engineering Services, Hanford, Richland, Washington.

Jordan, K. N. and H. L. Boston, 1998, *Tank Waste Remediation System Retrieval and Disposal Mission Readiness-to-Proceed Memorandum*, HNF-2019, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

Kirkbride, R. A., G. K. Allen, P. J. Certa, A. F. Manuel, R. M. Orme, L. W. Shelton, E. J. Slaathaug, R. S. Wittman, and G. T. MacLean and D. L. Penwell (SESC), 1997, *Tank Waste Remediation System Operation and Utilization Plan*, HNF-SD-WM-SP-012, Rev. 0, Vol. I and II, Numatec Hanford Corporation, Richland, Washington.

Kriskovich, J. R., 1998, *Slurry Distributor Affects on Ventilation System,* HNF-2783, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Papp, I. G., 1998, *Waste Feed Delivery Technical Baseline Document, Volume II Waste Feed Delivery Flowsheet*, HNF-1939, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

PHMC, 1997, *Operating Specifications for Aging Waste Operations in 241-AY and 241-AZ,* OSD-T-151-00017, Fluor Daniel Hanford, Richland, Washington.

Powell, M. R., G. R. Golcar, C. R. Hymas, and R.L. McKay, 1995, *Fiscal Year 1993 1/25-Scale Sludge Mobilization Testing*, PNL-10464, Pacific Northwest Laboratory, Richland, Washington.

Rieck, C. A., 1998, *Interface Document, Project W-211, Initial Tank Retrieval Systems*, HNF-1507, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

Taylor, W. J., 1998, *Contract No. DE-AC06-96RL13200 - Evaluation of Tanks Waste Disposal Second Alternative Within Privatization*, Letter 98-WDD-062, to R. F. Green, FDH (May 27), U.S. Department of Energy-Richland Operations Office, Richland, Washington.

Umek, A. M., 1998, *A Tank Waste Remediation System Privatization - Hanford Management Contractor Declaration of Readiness to Proceed with Phase 1B, Tank Waste Remediation System Privatization (Performance Agreement TWR 2.4.2)*, Letter FDH-9757162A R2, to W. J. Taylor, RL, (January 12), Fluor Daniel Hanford, Inc., Richland, Washington.

APPENDIX A

WASTE PREPARATION AND TRANSFER SYSTEMS PROCESS NEEDS AND ASSESSMENT

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APPENDIX A

WASTE PREPARATION AND TRANSFER SYSTEMS PROCESS NEEDS AND ASSESSMENT

Table 4-1 contains quantitative process needs that must be met in order to enable the Tank Waste Remediation System (TWRS) to adequately deliver appropriate waste feed during Phase 1 privatization. A number of these quantitative process needs are specific to and rely on specific performance of the waste preparation and transfer systems which must be present to support feed delivery to the Phase 1 privatization contractor as well as ongoing TWRS operations (e.g., single-shell tank [SST] waste retrieval) during the Phase 1 privatization time frame. For the purposes of this evaluation of 241-AZ tank farm, the waste preparation and transfer systems have been categorized into three major subsystems: mixer pumps; transfer pumps, piping and valving; chemical addition and flushing. The quantitative process needs identified in Table 4-1 that apply to each of these subsystems is presented in the sections below.

A.1 MIXER PUMPS

The alternative case in DeLozier (1998) identifies tanks 241-AZ-101 and 241-AZ-102 as being retrieved as high-level waste (HLW) feed. Additionally, these two tanks serve as HLW feed staging tanks for additional HLW retrieved from other tanks. Although the Management and Integration (M&I) contractor team no longer is responsible for establishing sludge washing capability, the HLW feed must consist of relatively homogenous slurry transferred in batches as often as once monthly. Mixer pumps must be installed in both tanks which can homogeneously suspend the solids now present in the tanks as well as future HLW transferred to these HLW feed staging tanks.

A.1.1 PROCESS NEEDS

The quantitative process needs which apply to the waste preparation and transfer system, including mixer pumps, are summarized as part of Table A-1 below. The mixer pumps are required to suspend the solids in tanks 241-AZ-101 and 241-AZ-102.

A.1.2 EXISTING AND PLANNED MIXER PUMPS

Project W-151 has installed two 224-kW (300-hp) mixer pumps into 241-AZ-101. These mixer pumps are scheduled to be tested during fiscal year 1999. Project W-211 is scheduled to put two 224-kW (300-hp) mixer pumps into 241-AZ-102. Design of the system to be installed into tank 241-AZ-102 is scheduled to begin in September of 1998 and construction is scheduled to be complete in September of 2002 (DeLozier 1998). It is important to note that these dates are a departure from the current W-211 Project schedule.

A.1.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO EXPECTATIONS

Table A-1 lists process needs and compares those process needs to capabilities of existing and planned equipment. Mixer pumps are not currently installed in tank 241-AZ-102 Project W-211 has planned to place two 224 kW (300 horse power) mixer pumps into 241-AZ-102 Based on sludge mobilization testing (Powell et al. 1995), the mixer pumps are thought to be capable of mobilizing waste solids. It is important to note that a full scale test of a two mixer pump systems ability to mobilize sludge has not yet been performed. There are two mixer pumps located in Tank 241-AZ-101, and a full scale test using this system is scheduled to occur in May or June 1999.

A potential issue with the current Project W-211 mixer pump design is that the intake and outlet of the mixer pumps are located near the bottom of the pump. The sludge in at least some of the tanks is extremely viscous, and will resist pumping. It is not clear from the current design how the pumps are to be started. If a sufficient amount of water cannot be added to the tank near the inlet of the mixer pumps, it will be very difficult or perhaps impossible to start the pumps without causing cavitation and potential failure of the pumps. It may be beneficial to redesign mixer pumps which will be added to tanks in the future such that the intake is located in the supernate and the discharge at the bottom to allow the mixer pumps to be started without cavitating.

A.2 TRANSFER PUMPS, PIPING, AND VALVE ROUTINGS

The RTP (Jordan and Boston 1998) identifies the projected transfers occurring in all tank farms through October 2011. The projected transfers are no longer fully consistent with the alternative case identified in DeLozier (1998). Both the previous set of transfers associated with sludge washing and the new set of transfers associated with DeLozier 1998 are identified in Table A-2. The set of transfers consistent with DeLozier 1998 will be examined as the set of transfers supporting waste feed delivery and all other relevant tank farm operations specific to 241-AZ.

A.2.1 PROCESS NEEDS

The quantitative process needs associated with transfer pumps and pipe routings are identified in table A-1 below. The transfer pumps and piping systems design must satisfy the process needs identified here. It is important to note that at the time of this writing, transfer pump design for the 241-AZ Tank Farm is not complete. An alternatives generation and analysis process should be followed to select an optimum transfer pump design. Piping systems are planned but not currently in place.

A.2.2 EXISTING AND PLANNED TRANSFER PUMPS AND PIPING AND VALVE ROUTINGS

Table A-3 postulates a route for each transfer between tanks that is identified in table A-2 consistent with DeLozier 1998. Table A-3 identifies whether all transfer equipment for tank to tank transfers either exists or is planned based on best available drawings, project documents, and other available information. Table A-3 is also used to compare the existing and planned transfer route equipment to the process needs. This comparison is discussed below.

A.2.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

A.2.3.1 Comparison of Existing and Planned Piping and Valving Routings to Process Needs

Table A-3 provides a transfer equipment availability matrix identifying whether equipment is currently installed (and planned to remain installed rather than be removed as part of an existing project) or whether the equipment is within the planned scope of a project.

A.2.3.2 Comparison of Existing and Planned Transfer Pumps to Process Needs

All planned transfers from 241-AZ tank farm are slurry transfers with up to 200 grams solids per liter. Table A-4 provides a transfer pump matrix identifying whether a transfer pump is currently installed (and planned to remain installed rather than be removed as part of an existing project) or whether the necessary equipment is within the planned scope of a project. The type of pump planned for each transfer is also identified as well as the equivalent length of the transfer. The equivalent length of the transfer is used in determining the adequacy of the particular pump in meeting the process needs. The equivalent length is calculated by combining straight line length with length factors for various fittings and bends. Equivalent length and overall changes in height (hydraulic head) for portions of the various transfer routes is identified in Table A-5.

Figures A-1 through A-4 show operating curves for each of the routings for solutions with a specific gravity of 1.41 and viscosities of 0.10, 0.15, 0.20, and 0.30 Pa•sec (10, 15, 20 and 30 cP) plotted against the head curve provided by a pump design for Project W-211. For the purpose of this document it is assumed that the transfer pumps selected for the 241-AZ tanks will have characteristics equivalent to those of the W-211 Project pump design for 241-AP-102 and 104. The flow rate for a transfer is estimated by the location where the operating curve intersect the pump curve. A sample calculation which demonstrates how the curves were developed is included in Appendix F. The planned pumps for the 241-AN tank Farm are capable of delivering waste at 1.8 to 2.7 M/sec. for transfers from the 241-AZ tanks provided the viscosity is maintained at 0.03 Pa•sec (30 cP) or below.

A.2.4 TRANSFER LINE DRAINING FOLLOWING FLUSHING

Most of the transfer piping is sloped allowing waste and flush solutions to drain. Peaks and valleys in transfer pipelines are unfavorable because these sections can cause holdup of solids, eventually leading to line plugging. Peak or valley sections also lead to siphoning. Abrupt changes in slope in transfer pipelines can also be areas which favor solids build up and eventual line plugging. For 241-AZ-101 tank, the transfer line between 241-AZ-101 and the new AZ Valve Pit is sloped toward AZ-101. The transfer line between 241-AZ-01A pump pit and 241- AZ-02A pump pit slopes toward 241-AZ-02A pump pit. Table A-5 lists the hydraulic change in each line. Table A-5 lists the beginning and ending points of each line for convenience because solutions can flow in either directions in the lines. A positive hydraulic change indicates a rise and a negative change indicates a drop. Figure A-5 graphically portrays the hydraulic diagrams for transfers to and from 241-AZ tank farm.

Figure A-5 is a hydraulic diagram of the transfers originating or terminating in the 241-AZ Tank Farm. In some cases lines not involved in the transfer may need to be used to route draining and/or flush solutions. As an example, transfers from 241-AY-101 or -102 will most likely pass through the new AZ-Valve Pit. The new AZ-Valve Pit will be hydraulically lower than either 241-AY-101 or 102 Pump Pits Tanks in 241-AP are hydraulically higher than the new AZ Valve Pit, tanks in 241-AN and in 241-AZ are hydraulically lower than the new AZ Valve Pit. Transfers from either 241-AY-101 or 102 to the AP Tank Farm or to the Private Vendor will tend to drain to the new AZ Valve Pit.

A.3 CHEMICAL ADDITION AND FLUSHING SYSTEM

A.3.1 PROCESS NEEDS

The first need for water addition is during the retrieval of the final batches of waste being transferred from either tank in 241-AZ to the private contractor. This water is added to aid in suspension of solids during transfer of the last few batches of solids from the tanks. Also, inhibited water is added to the transfer line upon completion of a transfer to remove residual material from the line. The quantitative process needs associated with these water additions is presented in Table A-1.

A.3.2 EXISTING AND PLANNED CHEMICAL ADDITION AND FLUSHING SYSTEM

The current flush system is not capable of delivering dilution water or flush solution at the required rate of 530 L/min, and the new chemical addition and flushing system design for the 241-AN Tank Farm has not yet been completed. For the purpose of this document it is assumed that the chemical addition and flushing system design will be functionally identical to the chemical addition and flushing system design for the 241-AP Tank Farm. The chemical addition and flushing system design for the 241-AP Tank Farm consists of a tank, heater(s), chemical metering pumps, and piping systems to deliver the flush/diluent. The system is designed to deliver up to 530 L/min of chemical adjusted (NaOH, NO_2, etc.) water at a temperature up to 66°C.

A.3.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO EXPECTATIONS

With the assumption that the 241-AN Tank Farm dilution system design will be functionally identical to the 241-AP Tank Farm dilution system design, the system will be capable of meeting the process needs identified in Table A-1. It is important to note, however, that the most likely diluent and flush solution is water without any added caustic or other chemicals.

A.4 REFERENCES

DeLozier, M. P., 1998, *Evaluation of Tank Waste Disposal Alternatives Within Privatization*, Letter LMHC-9854671A R1, to A. M. Umek, FDH, Subonctract number 80232764-9-K001, (June 15), Lockheed Martin Hanford Corporation, Richland, Washington.

Jordan, K. N., and Boston, H. L., 1998, Rev. 1, *Tank Waste Remediation System Retrieval and Disposal Mission Readiness-to-Proceed Memorandum*, HNF-2019, prepared by Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.

Julyk, L. J., 1997, *Evaluation of the Effect of Project W-151 Mixer Pump Jets on In-Tank Equipment Considering Potential Sludge Buildup on Equipment in Waste Tank 241-AZ-101 Hanford Site, Richland, Washington*, HNF-SD-W151-DA-008, Rev. 0, Fluor Daniel Northwest, Richland, Washington.

LANL, 1995, *A Safety Assessment for Proposed Pump Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101*, LA-UR-92-3196, Rev. 14, Los Alamos National Laboratory, Los Alamos, New Mexico.

Powell, M. R., 1995,, *Fiscal Year 1993 1/25-Scale Sludge Mobilization Testing*, PNL-10464, Pacific Northwest Laboratory, Richland Washington.

Rieck, C. A., 1998, *Interface Document, Project W-211, Initial Tank Retrieval Systems*, HNF-1507, Rev. 0.

Willis, W. L., W. A. Peiffer, B. B. Peters, and T. L. Waldo ,1998, *Evaluation of Tank Waste Transfers at 241-AW Tank Farm*, HNF-2238, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
5A.P1.1.mobilize >90% of the solids initially in 241-AZ-101, >60% of the solids initially in 241-AZ-102, and >99% of the solids transferred to these tanks from 241-AY-102.	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102	TBD	Although there are two 300 hp mixer pumps currently installed in tank 241-AZ-101, these pumps have not yet been tested. The test to verify the ability of the mixer pumps to mobilize the waste solids is scheduled to occur early summer of 1999.	Although there are two 300 hp mixer pumps currently installed in tank 241-AZ-101, these pumps have not yet been tested. The test to verify the ability of the mixer pumps to mobilize the waste solids is scheduled to occur early summer of 1999.
5A.P3.1. Equipment used to suspend or mobilize waste shall be able to operate under both normal startup and operation conditions (Note: for the currently installed system /in AZ-101 and the planned system for AZ-102, prevent cavitation of the mixer pump during normal startup and operation conditions).	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102	TBD	The mixer pumps currently installed in AZ-101 have not been operated as of the date of this writing. The mixer pumps include the ability to add diluent water near the pump intake through a sparge ring. Drawing H-14-102086 shows a typical mixer pump design which includes a sparge ring which will allow the addition of water near the pump intake. It is not known if this feature will be sufficient to allow the mixer pumps to start and prevent cavitation.	The mixer pumps currently installed in AZ-101 include the ability to add diluent water near the pump intake. Drawing H-14-102086 shows a typical mixer pump design which includes a sparge ring which will allow the addition of water near the pump intake. It is not known if this feature will be sufficient to allow the mixer pumps to start or operate.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
5A.P3.3. Equipment used to mobilize or suspend waste shall not impart excessive force to the tank structure. (Note: for the currently planned system - Provide mixer pumps which will not damage the tank structure during nomal and/or off-normal operation.)	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102	Yes	The loads of the mixer pump jets on in-tank equipment were evaluated in HNF-SD-W151-DA-008, Rev. 0 (Julyk 1997) indicates that for clean components, only minor damage may occur to a radiation dry well and to five air lift circulator thermowells. The damage postulated does not fail the equipment. In the case of components with a sludge buildup, the same components which were damaged in the case of clean equipment evaluated above, but the postulated foces may cause failure of those components.	
5A.P3.4. Provide a diluent system and a water addition line to allow addition of up to 379 m^3 (100,000 gal) of raw water near the intake of each mixer pump. The dilution system should be capable of providing the quantity at a flow rate of TBD liters per minute and a temperature range of 20°C to 50°C (+/- TBD °C). No cooling capacity is required.	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102 which allow liquid to be introduced into the pump intake	Yes	Drawing H-14-102451 shows a 1½ in. hose connection to a sparge ring near the pump intake. This configuration can be used to introduce water near the mixer pump intake. The total volume of water is not limited by the diluent addition system but it is limited by the allowable volume in the tank.	

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
5A.P3.5. Control the rate of operation of equipment used to mobilize and suspend solids. (Note: for the currently planned system - Provide mixer pumps with a variable frequency drive (VFD) capable of operating the pump from a minimum speed of approximately 58% speed to full speed operation.)	W-151 for AZ-101 W-211 will provide mixer pumps and Variable Frequency Drive unit for AZ-102	Yes for 101-AZ Yes for 102-AZ	VFD for AZ-101 mixer pump installed under W-151. HNF-1507 (Rieck 1998) page 85 and 14 indicates that a mixer pump with a VFD is to be installed into 102-AZ, the lower limits in the range of the VFD are not listed.	Project documentation needs to identify the range of operation of planned equipment.
5A.P3.6. Provide in-tank components which can withstand forces imparted by solids mobilization and suspension equipment and remain operable and retrievable from the DST. (Note for the currently planned system - Provide (or replace) in-tank components which can withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST.)	All existing and future in tank equipment	TBD	HNF-SD-W151-DA-008 is an evaluation of the effect of the mixer pump outflow on tank and tank internals. LANL document LA-UR-92-3196 (LANL 1995) for SY-101 is an evaluation of the effects of mixer pump generated missles on the tank and tank internals. This report needs to be repeated using two 224 kW (300 hp) mixer pumps versus the one 112 kW (150 hp) pump as in the SY-101 report.	HNF-SD-W151-DA-008 is an evaluation of the effect of the mixer pump outflow on tank and tank internals. LANL document LA-UR-92-3196 (LANL 1995) for SY-101 was an evaluation of the effects of mixer pump generated missles on the tank and tank internals. This report needs to be repeated using two 224 kW (300 hp) mixer pumps versus the one 112 kW (150 hp) pump as in the SY-101 report.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
5A.P3.7. Provide solids mobilization and suspension equipment which will not damage the tank structure during normal and/or off-normal operation. (Note: for the currently planned system - Provide mixer pumps which will not damage the tank structure during normal and/or off-normal operation.)	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102 which will limit the effect of discharge such that tank structure is not damaged.	TBD	HNF-SD-W151-DA-008 evaluates the effect of the mixer pump outflow on tank and tank internals. LANL document LA-UR-92-3196 (LANL 1995) for SY-101 evaluates the effects of mixer pump generated missles on the tank and tank internals. This report should be repeated using two 224 kW (300 hp) mixer pumps versus the one 112 kW (150 hp) pump as in the SY-101 report.	HNF-SD-W151-DA-008 evaluates the effect of the mixer pump outflow on tank and tank internals. LANL document LA-UR-92-3196 (LANL 1995) for SY-101 evaluates the effects of mixer pump generated missles on the tank and tank internals. This report should be repeated using two 224 kW (300 hp mixer pumps versus the one 112 kW (150 hp) pump as in the SY-101 report.
5B.P1.2 Mix tank contents to provide <TBD% variability of suspended HLW solids concentrations over the full depth prior to sampling and prior to beginning each feed transfer.	Existing mixer pumps in AZ-101 and Project W-211 provided mixer pumps in AZ-102	TBD	Although there are two 300 hp mixer pumps currently installed in tank 241-AZ-101, these pumps have not yet been tested. The test to verify the ability of the mixer pumps to mobilize and homogenize the waste solids is scheduled to occur early summer of 1999.	
5B.P2.1. Provide capability for addition of 379 m^3 (100,000 gal.) Of inhibited water to AZ-101 and 102 for each of the final two slurry transfers to the Privatizatio Contractor. The inhibited water shall meet the minimum corrosion specifications of 0.01<u>M</u> OH^- and 0.011<u>M</u> NO_2^-.	Project W-211 provided dilution/flush system	Yes	HNF-1507 (Rieck 1998) the dilution/flush system planned for 241-AN will also supply diluent to 241-AZ. The dilution/flush system for 241-AN will be capable of providing up to 530 L/min (140 gal/min) of inhibited water at a temperature up to 82°C (180°F).	Although the chemical addition listed in HNF-1507 is limited to NaOH, it is assumed that $NaNO_2$ additions could be made with the same system.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
9.P1.1. Provide transfer system capable of achieving a waste transfer velocity of 1.8-2.7 m/sec (6-9 ft/sec)	AZ-101 - Project W-521 AZ-102 Project W-211 provided transfer Pump and existing and project provided piping system.	Yes (See caveat in Comments/Issues) Yes (See caveat in Comments/Issues)	Project W-521 is planning to install a transfer pump into Tank AZ-101 Project W-211 is scheduled to install a transfer pump into Tank AZ-102. Appendix A develops the adequacy of the transfer system to transfer waste at 1.8 to 2.7 m/sec (6 to 9 ft/sec) with the assumption that the transfer pumps in AZ will have a pump curve equivalent to the Sulzer Pump curve used in the evaluation. See figures A.1 - A.4 and Section F.2.1 in Appendix F.	It is important to note that although the flex hose will likely not be used in AZ-101 or 102, the pump curve for the Sulzer - Bingham Pump was used to estimate flow performance.
9.P1.2. Provide transfer pumps with a water addition feature that will provide slurry dilution capability at the pump suction. The needed dilution water flow rate is 530 L/min (140 gal/min).	AZ-101 W-521 project provided transfer pump AZ-102 W-211 project provided transfer pump with provision for in-line dilution at transfer pump suction , and flush/diluent piping	AZ-101 - TBD AZ-102 - Yes	Design for a transfer pump for AZ-101 has not been initiated. HNF-1507 (Rieck 1998) Pages 85 & 14. The diluent/flush system for 241-AN, AY and AZ is not currently designed. The flush dilution system for 241-AP has been designed and is designed to be capable of delivering the required flow rate of diluent to the transfer pump intake. Assuming the design for 241-AZ will be functionally identical to the 241-AP design, the system will be adequate.	

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
9.P3.1. In normal operation, maintain the transfer system pressure drop below the transfer line operating pressure. The maximum line operating pressure can vary between 15.8 kPa to 27.6 kPa (230 to 400 psi) depending on the transfer line.	AZ-101: Project W-521 AZ-102: Project W-211 provided transfer pump and existing and project provided piping system.	Yes	The largest operating pressure in the piping system under normal conditions is in the transfers from AZ-102 to the private vendor where the pressure is 130 m (425 ft) of head which for a 1.41 specific gravity solution is approximately 17.9 kPa (260 psi). See figures A.1 through A.4 and the calculation in Section F.2.1.	The maximum allowable operating pressure of the piping system is 27.6 kPa (400 psi), this pressure must not be exceeded in normal operation
9.P3.2. Provide transfer pumps with a maximum design head of 137 m (450 ft) (TBR) total dynamic head at the target flow rate of 0.73 ML/day (140 gal/min).	AZ-101 - Project W-521 to provide transfer pump AZ-102 - Project W- 211 provided transfer pump and existing and W-314 Project provided Piping System	Yes	The largest operating pressure in the piping system under normal conditions is in the transfers from AZ-102 to the private vendor where the head is 130 m (425 ft). See figures A.1 through A.4 and the calculation in Section F.2.1.	
9.P3.3. Prevent cavitation of the transfer pump during normal startup and operation conditions. Net positive suction head required should not exceed Net Positive Suction Head Available at highest reasonable operating temperatures.	AZ-101 - Project W-521 provided transfer pump AZ-102 - Project W-211 provided transfer pump	TBD	The net positive suction head requirements are calculated in HNF-2238, Appendix E (Willis et al. 1998) and are met by the system.	Although the net positive suction head requirements are met by the system, it is not known wether the system will be capable of preventing the transfer pump intake from being buried in a sludge layer which may induce cavitation and lead to damage to or failure of the transfer pump.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
9.P3.4. Provide transfer pumps with a VFD capable of operating the pump from a minimum speed of approximately 25% speed to full speed operation (WHC-SD-WM-DGS-006, Rev. 0).	AZ-101 - Project W-521 provided transfer pump W-211 provided transfer pump and Variable Frequency Drive unit for AZ-102	TBD for 101-AZ TBD for 102-AZ	Transfer pump for AZ-101 has not yet been designed. HNF-1507 (Rieck 1998) page 85 and 14 indicates that a transfer pump with a VFD is to be installed into 102-AZ, the lower limits in the range of the VFD are not listed.	Project documentation needs to identify the range of operation of planned equipment.
9.P3.5. Provide reverse rotation and back flow protection for transfer pumps (WHC-SD-WM-DGS-006, Rev. 0).	AZ-101 - none AZ-102 - Project W-211 provided transfer pump	TBD	Transfer pumps for AZ-101 and 102 have not yet been selected. HNF-1507 does not indicate back flow prevention for the transfer pumps.	Transfer pumps for AZ-101 and 102 have not yet been selected. HNF-1507 does not indicate back flow prevention for the transfer pumps.
9.P3.6. Provide slurry transfer pumps which can be operated during mixer pump operation and withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST	AZ-101 - none* AZ-102 Project W-211 provided mixer and compatible transfer Pumps	TBD	Although both mixer pumps and transfer pumps are included in the W-211 design documentation no evaluation of the compatibility of the two were found.	* Any transfer pump to be installed into AZ-101 will need to be shown to be compatible with the existing mixer pumps in that tank. Although both mixer pumps and transfer pumps are included in the W-211 design documentation no evaluation of the compatibility of the two were found.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
9.P3.8. Provide transfer system components capable of transferring waste with a density as high as 1.4 g/ml.	AZ-101- none AZ-102 Project W-211 provided transfer Pump	AZ-101 - No AZ-102 - Yes	No project currently has scope to install a transfer pump into 101-AZ Sulzer-Bingham Pump curve included in HNF-2238 page D-16 (same pump assumed here) shows a horse power required curve for a Specific gravity of 1.5.	It is important to note that although the flex hose will likely not be used in AZ-101 or 102, the pump curve for the Sulzer - Bingham Pump was used to estimate flow performance.
9.P3.9. Provide transfer system components capable of handling wastes with a pH of 7 or greater.	AZ-101 - none Transfer Pump Design	AZ-101 - No AZ-102 - TBD	to be developed	to be developed
9.P3.10 Provide a transfer system which prevents the occurrence of water hammer resulting from reconfiguration of the system during the transfer.	Existing and Projects W-314 and W-211 provided transfer piping and jumper systems	TBD	An evaluation of the system will need to be performed which will demonstrate adequacy.	
9.P4.1. Provide a diluent system to flush the transfer lines with raw or inhibited water at 530 L/min (140 gal/min) (TBR).	Project W-211 provided dilution/flush system	Yes	HNF-1507 pages 65-66 and 36-38. The diluent/flush system for 241-AN, AY and AZ is not currently designed. The flush dilution system for 241-AP has been designed and is designed to be capable of delivering the required volume of diluent required. Assuming the design for 241-AN will be functionally identical to the 241-AP design, the system will be adequate.	*It is important to note that while AZ-102 is included within the scope of Project W-211, AZ-101 is not it has been assumed here that AZ-101 would have flush and diluent provided by the same system as AZ-102.

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
9.P4.2. The flush direction should be from the applicable 241-AZ pump pit to the Privatization Contractor facility (TBR).	Project W-211 provided dilution/flush System and existing and project provided Transfer Piping System	*Yes	H-14-102086 shows typical design for diluent/flush delivery in 241-AP. Assuming that the design for 241-AZ will be functionally identical to the 241-AP design, the flush delivery will be from 241-AZ to the private contractor facility	*It is important to note that while the flush solution is introduced at 241-AZ, and the overall slope of the transfer lines is toward the private vendor, a high spot exists in the transfer route at the private vendor interface point. Siphoning will need to be evaluated as the design of the private facility matures.
9.P4.3. Flush transfer lines with water volumes equivalent to 1.5 times the transfer line internal volume.	Project W-211 provided dilution/Flush system	Yes	HNF-1507 (Rieck 1998) Pages 36-38 & 65-66. The diluent/flush system for 241-AN, AY and AZ is not currently designed. The flush dilution system for 241-AP has been designed and is designed to be capable of delivering the required volume of diluent. Assuming the design for 241-AN will be functionally identical to the 241-AP design, the system will be adequate. The total amount of diluent which can be added to a tank is not limited by the dilution/flush system but by the volume of the waste tank.	
9.P4.4. Flush water inlet can be at the transfer pump inlet or in the pump discharge line.	Project W-211 provided dilution/flush System and existing and project provided Piping System	Yes	H-14-102086 shows a typical layout for the dilution/flush delivery at the pump intake. The specific design for 241-AZ has not been started. Assuming that earlier designs are typical the design will be adequate.	

Table A-1. Comparison of Process Needs to Existing and Planned Equipment for Waste Preparation and Transfer Systems in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing or planned equipment adequate (Yes/No)	Basis for adequacy	Comments/issues
10.P2.1. In 241-AZ and 241-AY tanks, provide a drop leg or other method of discharging liquid beneath tank waste surface.	None	no	No project currently has this work within its identified scope.	

Table A-2. Summary of Tank Transfers to and from 241-AZ Tank Farm.

Transfer path		Transfer period	
From	To	Start date	End date
Transfers Under Baseline (Umek 1998)			
AZ-101	AN-105	11/21/03	3/7/04
AZ-101	AW-105	10/9/00	1/22/01
AZ-101	AY-101	8/17/00	8/20/00
AZ-101	P1HLW_FEED_TANK	5/17/02	10/27/07
AZ-102	AN-105	1/5/02	2/26/07
AZ-102	AP-107	11/15/01	11/16/01
AZ-102	AY-101	11/14/01	11/15/01
AZ-102	P1HLW_FEED_TANK	11/14/03	11/12/09
AP-107	AZ-101	6/11/09	6/13/09
AY-102	AZ-101	11/16/03	11/21/03
WASH-WATER	AZ-101	8/20/00	3/11/04
AY-102	AZ-102	8/1/05	8/3/05
WASH-WATER	AZ-102	11/16/01	2/28/07
Transfers Under Alternative Case (DeLozier 1998)			
AZ-101	P1HLW_FEED_TANK	6/2004	3/2005
AZ-102	P1HLW_FEED_TANK	4/2005	2/2006
AY-102 (with C-106)	AZ-101	5/2006	8/2007
AY-102 (from C-104)	AZ-102	8/2007	6/2009
WATER	AZ-101	6/2004	8/2007
WATER	AZ-102	4/2005	6/2009

Table A-3. 241-AZ Transfer System Equipment Availability Matrix.

Transfer	Transfer route	Equipment needs	Equipment installed		Equipment planned		References
			Yes (ID or label)	No	Yes (Project #)	No	
241-AY-102 to 241-AZ-101 (post 1999)	241-AY-102 Slurry Transfer Pump in AY-02A Pump Pit Riser 6A	Slurry Transfer Pump		No	Yes (W-211)		HNF-1507, Rev. 0, Section J.2.3
	Pump Pit 02A discharge nozzle to Nozzle U5 in AY-02A Pump Pit	Jumper or manifold between Pump and Nozzle U5		No	Yes (W-211)		ES-314E-M40, Rev. 10, 9/98; HNF-1507, Rev. 0, Section J.2.7
	Pump Pit AY-02A Nozzle U5 to 3 in. line SN-633 to Nozzle G in New AZ Valve Pit	7.6 cm (3 in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	New AZ Valve Pit Nozzle G to Nozzle H	Jumper or manifold between Nozzle G and Nozzle H		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle H to 3 in. line SN-632 to Nozzle U12 in AZ-101 Pump Pit AZ-01A	7.6 cm (3 in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle U12 in AZ-101 Pump Pit AZ-01A to tank return nozzle 3	Jumper or manifold between Nozzle U12 and tank return nozzle 3 (Riser 6A)		No	Yes (W-521)		ES-314E-M40, Rev. 10, 9/98
	Tank Return Nozzle 3 in Riser 6A	Discharge nozzle in tank 241-AZ-101		No	Yes (W-521)		ES-314E-M40, Rev 10, 9/98
241-AY-102 to 241-AZ-102 (post 1999)	241-AY-102 Slurry Transfer Pump in AY-02A Pump Pit Riser 6A	Slurry Transfer Pump		No	Yes (W-211)		HNF-1507, Rev. 0, Section J.2.3

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Table A-3. 241-AZ Transfer System Equipment Availability Matrix.

Transfer	Transfer route	Equipment needs	Equipment installed		Equipment planned		References
			Yes (ID or label)	No	Yes (Project #)	No	
241-AY-102 to 241-AZ-102 (post 1999) (Continued)	Slurry Transfer Pump discharge nozzle to Nozzle U5 in AY-02A Pump Pit	Jumper or manifold between Pump and Nozzle U5		No	Yes (W-211)		ES-314E-M40, Rev. 10, 9/98; HNF-1507, Rev. 0, Section J.2.7
	Pump Pit AY-02A Nozzle U5 to 3 in. line SN-633 to Nozzle G in New AZ Valve Pit	7.6 cm (3 in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	New AZ Valve Pit Nozzle G to Nozzle H	Jumper or manifold between Nozzle G and Nozzle H		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle H to 3 in. line SN-632 to Nozzle U12 in AZ-101 Pump Pit AZ-01A	7.6 cm (3 in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle U12 in AZ-101 Pump Pit AZ-01A to Nozzle U11	Jumper or manifold between Nozzle U12 and Nozzle U11		No	Yes (W-521)		ES-314E-M40, Rev. 10, 9/98
	Nozzle U11 to 3 in. line SN-631 to Nozzle U13 in AZ-102 Pump Pit AZ-02A	7.6 cm (3 in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle U13 in AZ-102 Pump Pit AZ-02A to tank return nozzle	Jumper or manifold between Nozzle U13 and tank return nozzle (Riser 6A)		No	Yes (W-211)		ES-314E-M40, Rev. 10, 9/98; HNF-1507, Rev. 0, Section J.2.7
	Tank Return Nozzle in Riser 6A	Discharge nozzle in tank 241-AZ-102		No	Yes (W-211)		ES-314E-M40, Rev. 10, 9/98; HNF-1507, Rev. 0, Section J.2.7

Table A-3. 241-AZ Transfer System Equipment Availability Matrix.

Transfer	Transfer route	Equipment needs	Equipment installed		Equipment planned		References
			Yes (ID or label)	No	Yes (Project #)	No	
241-AZ-101 to Phase 1 HLW Interface (post 1999)	241-AZ-101 Slurry Transfer Pump in AZ-01A Pump Pit Riser 6A	Slurry Transfer Pump		No	Yes (W-521)		ES-314E-M40, Rev 10, 9/98
	Slurry Transfer Pump discharge nozzle to Nozzle U12	Jumper or manifold between Pump and Nozzle U12		No	Yes (W-521)		ES-314-M40, Rev 10, 9/98
	Nozzle U12 to 7.6-cm (3-in.) line SN-632 to Nozzle H in New AZ Valve Pit	7.6-cm (3-in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	New AZ Valve Pit Nozzle H to Nozzle B	Jumper or manifold from Nozzle H to Nozzle B		No	Yes (W-314)		ES-314E-M40, Rev. 10, 6/98
	Nozzle B to 7.6-cm (3-in.) line SN-637 to HLW Privatization Contractor Interface	7.6-cm (3-in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
241-AZ-102 to Phase 1 HLW Interface (post 1999)	241-AZ-102 Slurry Transfer Pump in AZ-02A Pump Pit Riser 6A	Slurry Transfer Pump		No	Yes (W-211)		HNF-1507, Rev. 0, Section F.2.3
	Slurry Transfer Pump discharge nozzle to Nozzle U13	Jumper or manifold between transfer pump and Nozzle U13		No	Yes (W-211)		ES-314E-M40, Rev. 10, 9/98; HNF-1507, Rev. 0, Section F.2.3
	Nozzle U13 to 3 in. line SN-631 to Nozzle U11 in Pump Pit AZ-01A	7.6 cm (3-in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle U11 to Nozzle U12 in AZ-01A Pump Pit	Jumper or manifold from Nozzle U11 to Nozzle U12		No	Yes (W-521)		ES-314E-M40, Rev. 10, 9/98

Table A-3. 241-AZ Transfer System Equipment Availability Matrix.

Transfer	Transfer route	Equipment needs	Equipment installed		Equipment planned		References
			Yes (ID or label)	No	Yes (Project #)	No	
	Nozzle U12 to 7.6-cm(3-in.) line SN-632 to Nozzle H in New AZ VALVE Pit	7.6 cm (3-in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle H to Nozzle B in New AZ Valve Pit	Jumper or manifold from Nozzle H to Nozzle B		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98
	Nozzle B to 7.6-cm (3 in.) line SN-637 to HLW Privatization Contractor Interface	7.6 cm (3-in.) transfer line		No	Yes (W-314)		ES-314E-M40, Rev. 10, 9/98

Table A-4. Transfer Pump Availability Matrix.

Transfer	Transfer pump type needed	Equivalent length of transfer	Equipment installed	Equipment planned	References
			Yes (ID or label)/No	Yes (Project #)/No	
AZ-101 to HLW Interface (post 1999)	Slurry Transfer Pump/ Flexible Receiver Pump (Sulzer Pump)	1459 m (4788 ft)	No		
AZ-102 to HLW Interface (post 1999)	Slurry Transfer Pump/ Flexible Receiver Pump (Sulzer Pump)	1715 m (5627 ft)	No	Yes (W-211)	HNF-1507, Rev. 0, Interface Document, Project W-211, Initial Tank Retrieval Systems
AY-102 to AZ-101 (post 1999)	Slurry Transfer Pump/ Flexible Receiver Pump (Sulzer Pump)	329 m (1081 ft)	No	Yes (W-211)	HNF-1507, Rev. 0
AY-102 to AZ-102 (post 1999)	Slurry Transfer Pump/ Flexible Receiver Pump (Sulzer Pump)	561 m (1841 ft)	No	Yes (W-211)	HNF-1507, Rev. 0

Table A-5. Equivalent Line Length and Hydraulic Rise Values for Lines Involved in Waste Transfers.

Line number	Line length	Fittings/bends	Equivalent length	Hydraulic rise/fall
WT-SNL-3150 X-Site to AN-101	422 M	16 90° Ells 2 45° Ells	448 m (1470 ft)	-4.69 m (15 ft-4 ½ in.)
WT-SLL-3160 X-Site to AN-104	410.4 M	19 90° Ells 2 45° Ells	442 m (1450 ft)	-5.11 m (16 ft-9 in.)
3 in.SN-636 AN-104 to AP-104	480.4 M	24 90° Ells 2 45° Ells	521 m (1710 ft)	+2.73 m (8 ft-11 ½ in.)
3 in.SN-630 AN-101 to New AZ Valve Pit	102.8 M	9 90° Ells	117 m (383 ft)	+1.41 m (4 ft-7 ½ in.)
3 in.SN-632 AZ-101 to New AZ Valve Pit	36.8 M	4 90° Ells	43.0 m (141 ft)	+0.15 m (6 in.)
3 in.SN-633 AY-102 to New AZ Valve Pit	143.2 M	8 90° Ells 2 45° Ells	158 m (519 ft)	-1.83 m (6 ft-1/8 in.)
3 in.SN-634 New AZ Valve Pit to AP-Valve Pit	443.8 M	18 90° Ells 4 45° Ells	475 m (1560 ft)	+2.29 m (7 ft-6 in.)
3 in.SN-637 New AZ Valve Pit to HLW interface	362.6 M	15 90° Ells 2 45° Ells	387 m (1270 ft)	+1.32 m (4 ft-4 in.)
3 in. SN-261-M25 AN-101 to AN-B	69.7 M	7 90° Ells	80.5 m (264.2 ft)	+0.305 m (1 ft)
3 in.SN-262-M25 AN-102 to AN-B	35.3 M	5 90° Ells	43.1 m (141.4 ft)	+0.305 m (1 ft)
3 in.SN-263-M25 AN-103 to AN-B	26.3 M	5 90° Ells	34.1 m (111.9 ft)	+0.305 m (1 ft)
3 in.SN-264-M25 AN-104 to AN-A	67.4 M	5 90° Ells	75.1 m (246.5 ft)	+0.305 m (1 ft)
3 in.SN-265-M25 AN-105 to AN-A	33.8 M	5 90° Ells	41.6 m (136.5 ft)	+0.305 m (1 ft)
3 in.SN-266-M25 AN-106 to AN-A	30.8 M	5 90° Ells	38.6 m (126.5 ft)	+0.305 m (1 ft)
3 in.SN-267-M25 AN-107 to AN-A	64.4 M	6 90° Ells	73.7 m (241.9 ft)	+0.305 m (1 ft)
3 in.SN-268-M25 AN-A to AN-B	9.2 M	6 90° Ells	15.5 m (50.7 ft)	0
3 in.SN-611-M25 AP Valve Pit to AP-101	115.2 M	8 90° Ells	128 m (418.9 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-612-M25 AP Valve Pit to AP-102	119.1 M	8 90° Ells	128 m (431.4 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-613-M25 AP Valve Pit to AP-103	83.8 M	6 90° Ells	93.1 m (305.6 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-614-M25 AP Valve Pit to AP-104	86.4 M	6 90° Ells	95.7 m (314.1 ft)	-0.203 m (0 ft-8 in.)

Table A-5. Equivalent Line Length and Hydraulic Rise Values for Lines Involved in Waste Transfers.

Line number	Line length	Fittings/bends	Equivalent length	Hydraulic rise/fall
3 in.SN-615-M25 AP Valve Pit to AP-105	82.7 M	6 90° Ells	92.0 m (301.9 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-616-M25 AP Valve Pit to AP-106	94.3 M	6 90° Ells	104 m (340 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-617-M25 AP Valve Pit to AP-107	116.6 M	8 90° Ells	129 m (423.3 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-618-M25 AP Valve Pit to AP-108	122.5 M	8 90° Ells	135 m (442.7 ft)	-0.203 m (0 ft-8 in.)
3 in.SN-622-M9 Pump Pit 241-AP-02D to 241-AP-02A	11.8 M	3 90° Ells	16.5 m (54 ft)	+0.152 m (0 ft-6 in.)
3 in.SN-623-M9 Pump Pit 241-AP-04D to 241-AP-04A	11.8 M	3 90° Ells	16.5 m (54 ft)	+0.152 m (0 ft-6 in.)
3 in.SN-624-M9 Pump Pit 241-AP-04D to 241-AP-02D	43 M	4 90° Ells	45.7 m (150 ft)	-0.102 m (0 ft-4 in.)
3 in.SN-631-M25 AZ-102 to AZ-101	50 M	3 90° Ells	54.9 m (180 ft)	-0.610 m (2 ft)
3 in.SN-635-M25 AY-101 to AY-102	46.9 M	4 90° Ells	51.8 m (170 ft)	0
Generic Valve Pit	3.05 M	2 T-Port Valves (run) 1 T-Port Valve (branch) 3 PUREX Connectors 5 long radius 90° Elbow	62.5 m (205 ft)	0
Generic Pump Pit	3.66 M	2 PUREX Connectors 1 T-Port Valve (run) 2 long radius 90° Elbow	32.9 m (108 ft)	0
Line from the HLW interface to the Private Contractor Facility	1035 M	24 90° Ells	1072 m (3518 ft)	-5.44 m (17 ft-10 in.)

Figure A-1. Operating Curve Tank 241-AZ-101 to Private Vendor.

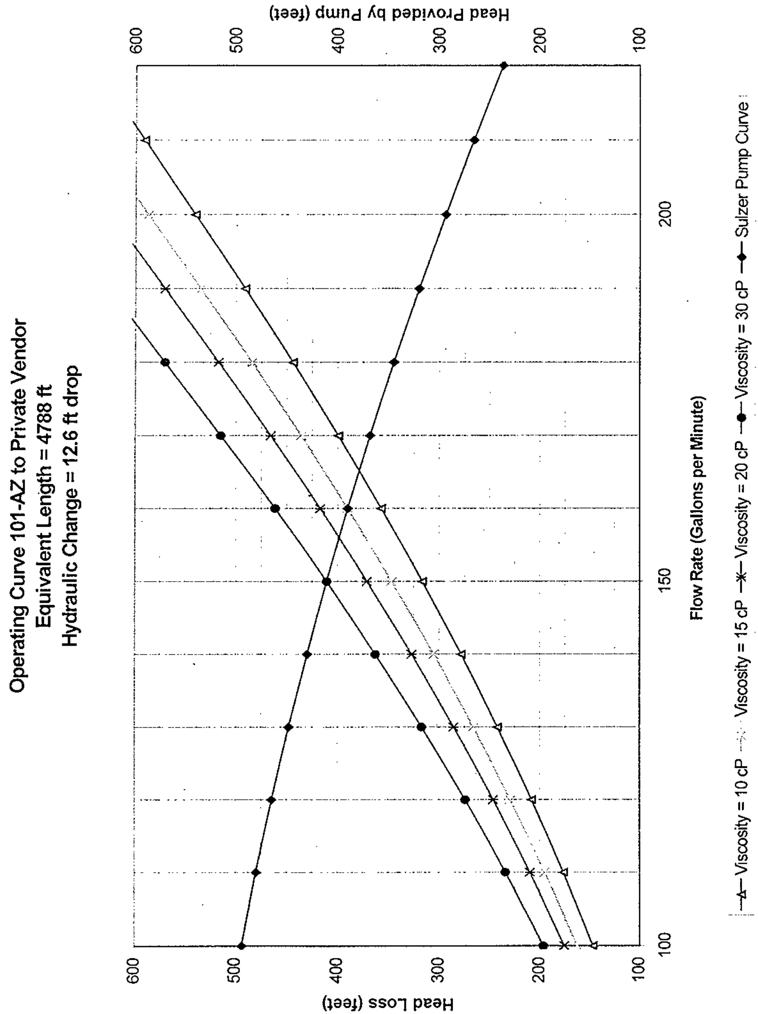


Figure A-2. Operating Curve Tank 241-AY-102 to 241-AZ-101.

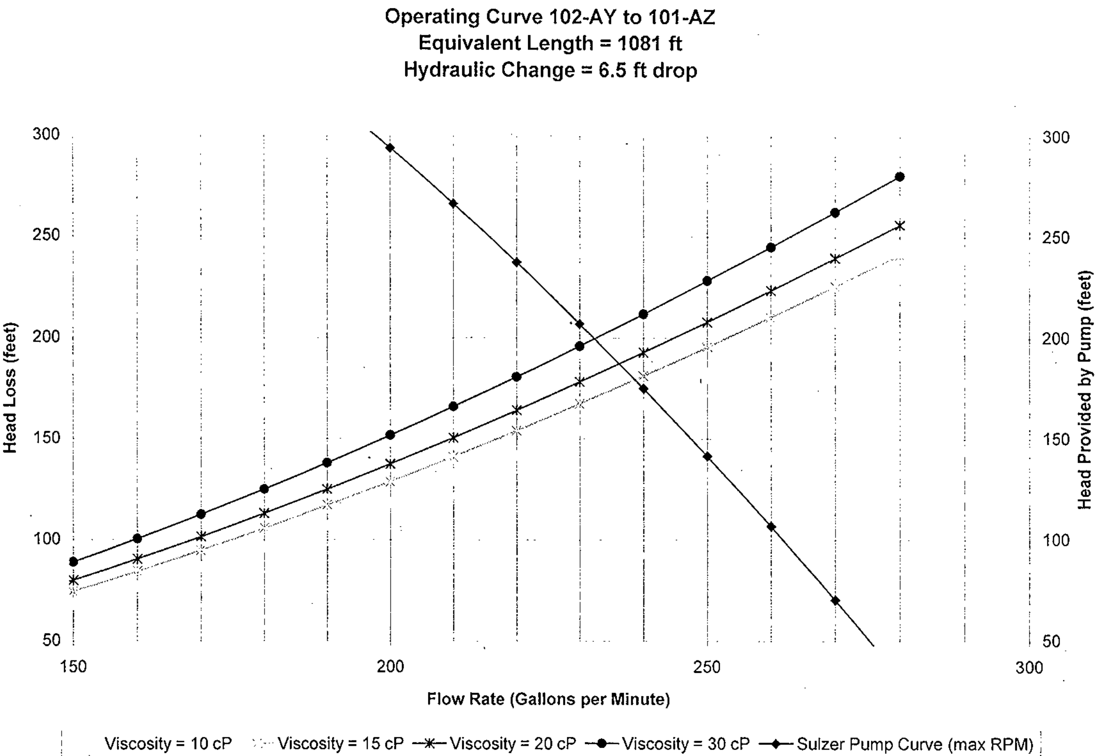


Figure A-3. Operating Cureve Tank 241-AZ-102 to 241-AY-101.

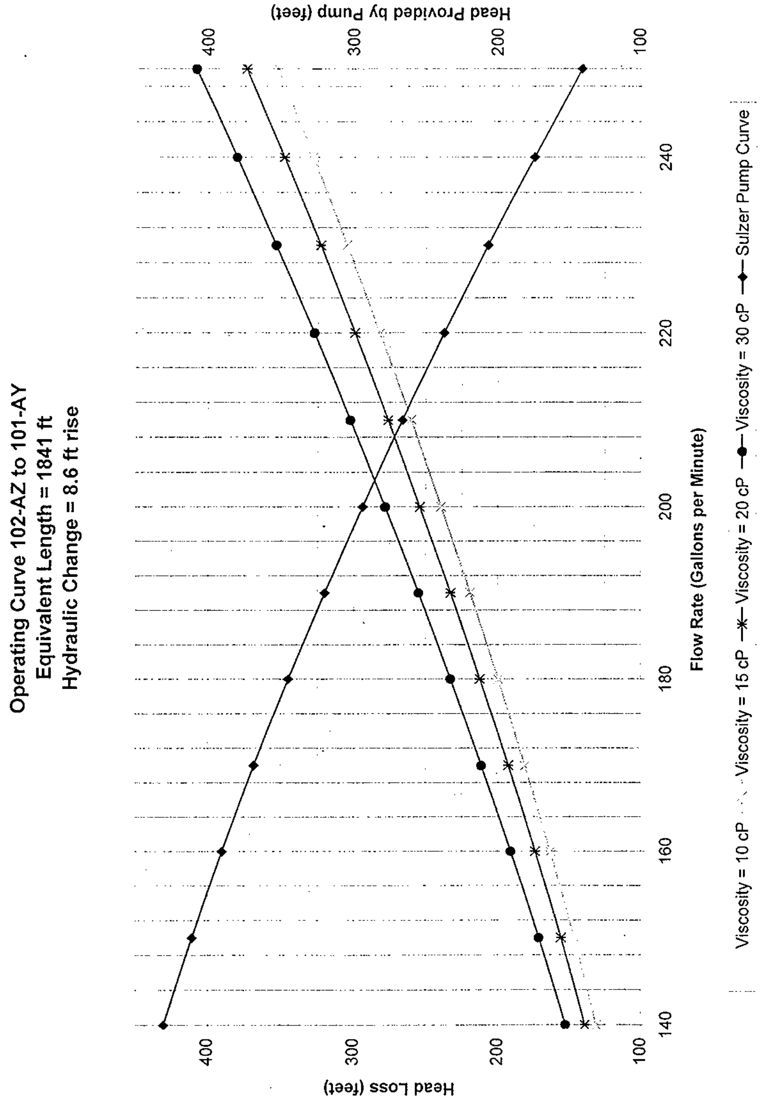


Figure A-4. Operating Curve 241-AZ-102 to Private Vendor Facility.

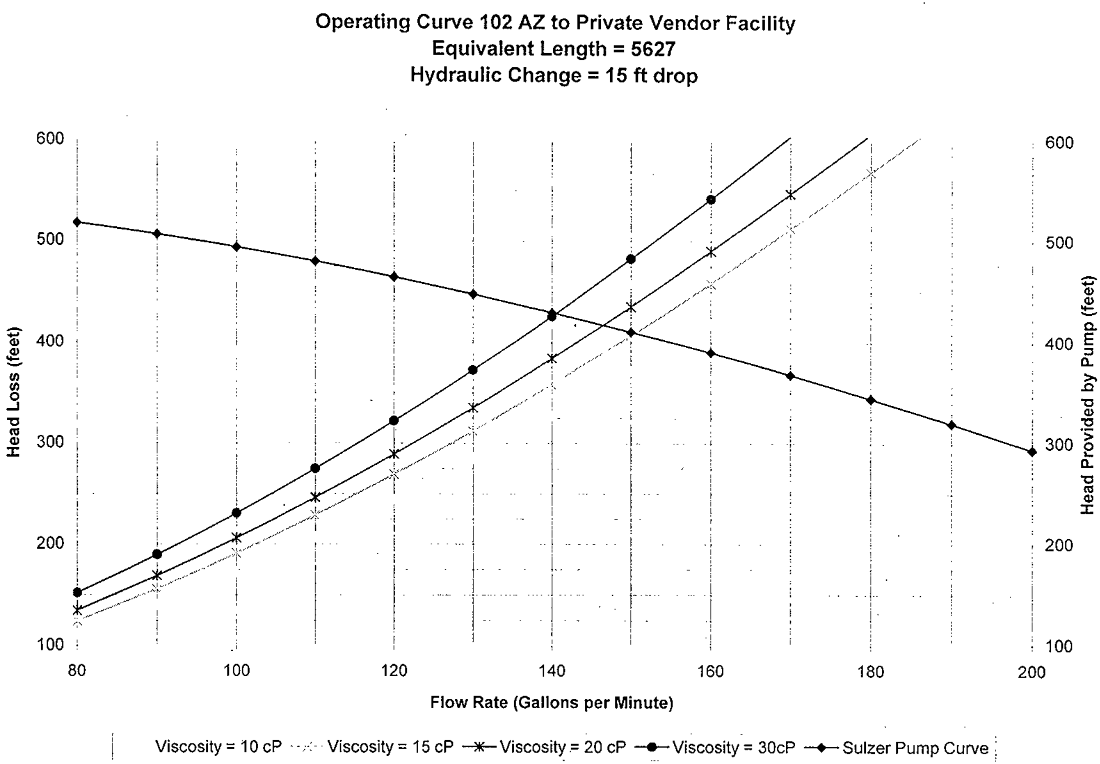
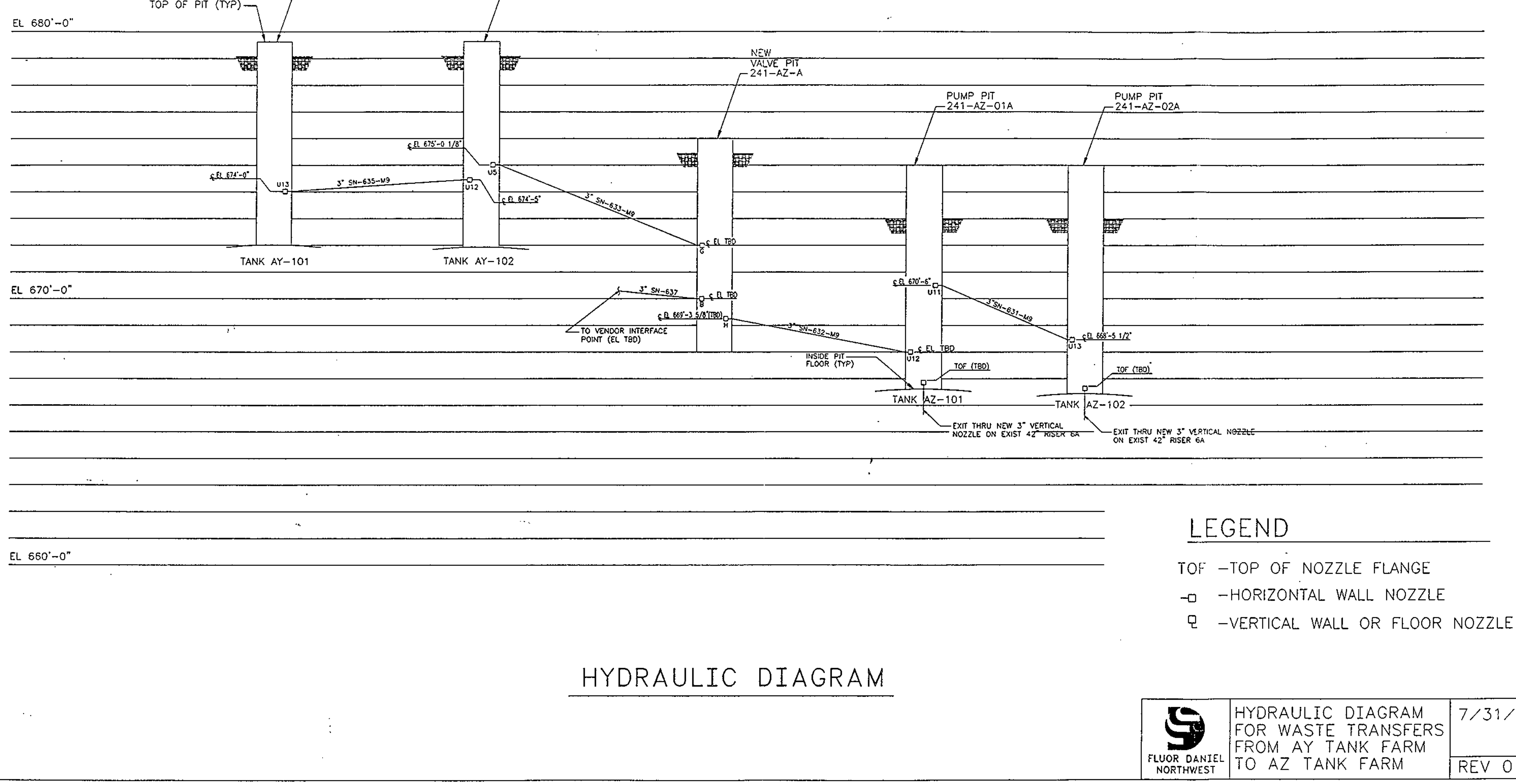


Figure A-5. Hydraulic Diagram for Waste Transfers from AY Tank Farm to AZ Tank Farm.



APPENDIX B

UTILITY DISTRIBUTION SYSTEM PROCESS NEEDS AND ASSESSMENT

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APPENDIX B

UTILITY DISTRIBUTION SYSTEM PROCESS NEEDS AND ASSESSMENT

Table 4-1 contains quantitative process needs that must be met in order to enable Tank Waste Remediation System (TWRS) to adequately deliver appropriate waste feed during Phase 1 privatization. A number of these quantitative process needs are specific to and rely on specific performance of the utility distribution systems which must be present to support feed delivery to the Phase 1 privatization contractor as well as ongoing TWRS operations (e.g., single-shell tank (SST) waste retrieval) during the Phase 1 privatization time frame. For the purposes of this evaluation of 241-AZ tank farm, the utility distribution systems have been categorized into four major subsystems: compressed and instrument air; raw water; electrical power and steam. The quantitative process needs identified in Table 4-1 that apply to each of these subsystems is discussed in the sections below. Table B-1 identifies whether existing or planned utility distribution systems are adequate to meet the process needs associated with Phase 1 privatization feed delivery.

B.1 COMPRESSED/INSTRUMENT AIR SYSTEM

B.1.1 PROCESS NEEDS

The quantitative process needs which apply to the utility distribution system, including compressed/instrument air, are summarized as part of Table B-1 below. Any transfer system instrumentation requiring compressed/instrument air is expected to receive it from the compressed/instrument air system for the 241-AZ tank farm.

B.1.2 EXISTING AND PLANNED COMPRESSED/INSTRUMENT AIR SYSTEM

The 241-AZ and 241-AY tank farms share an instrument air system which is located in the 701-A Building. It consists of two large capacity air compressors with a large capacity reservoir. Additionally, there are two emergency backups and generators. The system is capable of providing sufficient air to the Air Lift Circulators (ALCs) in the Aging Waste Facility. Therefore, any instrument air requirements can easily be accommodated by this system. This equipment is currently installed and can be verified as meeting the requirements

B.1.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

The 241-AZ tank farm transfer system contains one instrument requiring instrument air: the weight factor leak detectors in the leak detections pits. Because the compressed/instrument air system is sized to provide sufficient air flow to the ALCs, it is sufficient to provide instrument air to the weight factor leak detectors.

B.2 RAW WATER SYSTEM

B.2.1 PROCESS NEEDS

The quantitative process needs which apply to the utility distribution system, including raw water, are summarized as part of Table B-1 below. Raw water is expected to be supplied at variable flows with maximum flow rate of at least 530 L/min (140 gal/min) at 5.84 kPa (70 psi) to allow for in-line dilution for the transfer pumps, in-tank dilution and pipeline pre-heating and flushing.

B.2.2 EXISTING AND PLANNED RAW WATER SYSTEM

Currently, tanker trucks transport all raw water used in 241-AZ tank farm (Powell, 1998). The raw water is then delivered to the transfer line or tank via the tanker truck booster pump and some sort of jumper or connection to the transfer line.

The raw water system in 241-AZ tank farm will be upgraded by Project W-211 for 102-AZ waste dilution and pipeline flushing. Although a specific interface point has not been chosen, a number of options exist, Refer to HNF-1507, *Interface Document, Project W-211, Initial Tank Retrieval System*. The existing system will adequately support transfer line flushing operations.

B.2.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

The Project W-211 raw water system upgrade will provide raw water at 530 L/min (140 gal/min) and 5.84 kPa (70 psi) (Rieck 1998). Therefore, the future upgrade to the 241-AZ tank farm raw water system will be sufficient to support dilution and flushing activities.

B.3 ELECTRICAL POWER

B.3.1 PROCESS NEEDS

The quantitative process needs that apply to the utility distribution system, including electrical power, are summarized as part of Table B-1 below. The existing power distribution system for 241-AZ tank farm is not expected to allow operation of all existing equipment. Historical electrical metering data indicate that spare capacity does not exist to support the planned waste retrieval and transfer operations.

B.3.2 EXISTING AND PLANNED ELECTRICAL POWER DISTRIBUTION SYSTEM

The power system is described via two main functions, the electrical distribution system to the AZ farm and distribution within the farm.

The substation installed by Project W-151 is fed from 13.8 KV line number C8-L6. The capacity of this line is approximately 7 MW and the existing average demand load is approximately 3 MW.

The new substation installed by Project W-151 for AZ tank farm is being modified by Project W-211 to add variable frequency drives (VFDs) for two mixing pumps and a transfer pump in tank 241-AN-105, and to provide a dilution system to serve the AN, AY, and AZ tank farms. Transfer switches will be provided by Project W-211 to facilitate connection of future retrieval systems in other AN farm tanks. The system configuration will also allow operation of one mixer pump in each of AN and AZ farms simultaneously.

B.3.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

The power system is also evaluated by examining the two main required functions, the electrical distribution system to the AZ farm and the distribution within the farm.

The existing tank farms electrical supply may not be adequate to supply either the process need maximum load or the schedule based maximum electrical load. The process need load is more conservative than the postulated schedule load. The process need requires the independent operation of retrieval equipment in each of the four 200 East Area DST farms. This is equivalent to running two mixer pumps and one transfer pump in each farm, or, eight 224-kW (300-hp) mixer pumps and four 44 kW (60-hp) transfer pumps. The postulated schedule load is based on the integrated schedules. The integrated schedules show that at least once in each of the first three years of processing up to nine mixer pumps and one transfer pump may be needed simultaneously to suspend and transfer solids.

The capacity of the C8-L6 line is approximately 7 MW and the existing average demand load is approximately 3 MW. The power requirement for a pair of 224-kW (300-hp) mixing pumps and a 44-kW (60-hp) transfer pump is about 640 KVA. The simultaneous operation of nine mixer pumps (one set of mixers in each of 241-AY-102 (four 112-kW [150-hp]), AZ Farm (two 224-kW [300-hp]) and AN (or AW) Farm (two 224-kW [300-hp]) and one (224-kW [300-hp]) mixer in AP Farm) cannot be achieved. Load flow and voltage drop analysis of 13.8 KV line C8-L6 indicates that the line cannot provide power to the postulated schedule maximum TWRS load of nine mixer pumps and one transfer pump operating simultaneously without experiencing excessive voltage drop in the tank farm area. The voltage drop will also be excessive for the process need requirement since it is more conservative than the postulated schedule load. To resolve this potential issue the possibility of transferring some tank farm loads to other electrical supply lines in the area (lines C8-L5 and C8-L8 are the most likely candidates) could be explored. Or, a more detailed examination of schedule constraints for simultaneous operation of nine mixer pumps could be examined and the process need for independent operation of each farm can be modified. The load flow study is summarized in Appendix F.3.1. A load projection study is also in progress to evaluate the changes in other loads on the distribution line in future years.

The modifications being made by project W-211 will result in the existence of enough VFDs to operate four mixing pumps simultaneously. The 1000 KVA substation in 241-AN tank farm currently will have enough capacity to run two mixer pumps and two transfer pumps for the AN and AZ farms combined. However, the transformer will need to be upgraded to operate two mixer pumps and a transfer pump in each farm simultaneously. Overall, the process need to provide for the simultaneous operation of nine mixer pumps (one set of mixers in each of 241-AY-102 [four 112 kW (150 hp)], AZ Farm [two 224 kW (300 hp)] and AN [or AW] Farm [two 224 kW (300 hp)] and one 224-kW [300-hp] mixer in AP Farm) cannot be achieved.

In addition, it is uncertain at this time whether the 241-AN tank farm ventilation system would be able to support the effects of heat input from more than two mixer pumps operating at full speed (Rieck 1998).

In summary, the substation will operate two mixer pumps and two transfer pumps simultaneously in AN farm and/or AZ farm. However, the substation will require a transformer upgrade in order to operate two mixer pumps and a transfer pump in each farm simultaneously. In addition, the possibility of transferring some tank farm loads to other electrical supply lines in the area, e.g., lines C8-L5 and C8-L8 should be explored. Conversely, a detailed examination of schedule constraints for simultaneous operation of nine mixer pumps or the process need for independent operation of each farm may also be considered or required.

B.4 STEAM

B.4.1 PROCESS NEEDS

No process needs for steam have been identified for 241-AZ tank farm. Any 241-AZ tank farm transfer system components requiring steam are expected to receive it from the 241-AY tank farm steam coil system.

B.4.2 EXISTING AND PLANNED STEAM SYSTEM

The 241-AY tank farm steam coil system is capable of providing steam to the steam heater units in each of the waste tanks in the 241-AZ tank farm. However, these steam heater units are non-operational. The last time they were operated was in 1983, in support of plutonium-uranium extraction (PUREX) startup. The coils had developed considerable leaks at that time. Presently, the steam system is isolated from the steam heater coils (Powell 1998).

B.4.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO PROCESS NEEDS

The existing steam heaters are not required to meet any transfer system process needs. No needs for steam have been identified within the 241-AZ tank farm to support Phase 1 privatization. Therefore, the 241-AZ tank farm steam system is sufficient for waste feed delivery.

B.5 REFERENCES

Rieck, C. A., 1998, *Interface Document, Project W-211, Initial Tank Retrieval Systems,* HNF-1507, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

LMHC, 1998, *TWRS Administration Manual, Volume IV, Section 5.4*, HNF-IP-0842, Rev. 10g, Lockheed Martin Hanford Corporation, Richland, Washington.

LMHC, 1997, *Tank Waste Remediation System Technical Safety Requirements*, HNF-SD-WM-TSR-006, Rev 0-L, Lockheed Martin Hanford Corporation, Richland, Washington.

Table B-1. Comparison of Process Needs to Existing and Planned Equipment for Utilities in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
4.P2.1Provide capability for addition of approximately 379 m^3 (100,000 gal) of inhibited water to 241-AZ-101 and 241-AZ-102 for each of the final two slurry transfers to the Privatization Contractor. The inhibited water shall meet the minimum corrosion specifications of 0.01M OH^- and 0.011M NO_2^-.	Raw water system will feed the AZ farm and the dilution system.	Yes	Per HNF-1507, Appendix D, Section D.2.13.	Raw Water System is capable of providing water to the diluent system for treatment. The required flow rate must be specified to complete the evaluation of the system adequacy.
4.P2.2. Provide a diluent system and water addition line to allow addition of up to 341 m^3 (90,000 [TBR] gal) raw water near the intake of each mixer pump. The dilution system should be capable of providing this quantity at a flow rate of TBD gal/min.	Raw water system will feed the AZ farm and the dilution system.	Yes	Per HNF-1507, Appendix D, Section D.2.13.	Raw Water System is capable of providing water to the mixer pump systems. The required flow rate must be specified to complete the evaluation of the system adequacy.

Table B-1. Comparison of Process Needs to Existing and Planned Equipment for Utilities in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
5.P4.1. Provide for the independent operation of one set of mixer pumps in each of four 200 East Area DST farms and one transfer pump in a 200 East Area DST farm.[1] Provide control systems and electrical distribution systems which can support the simultaneous operation of up to nine mixer pumps and one transfer pump. The electrical distribution system shall have a capacity to run 9 pumps totaling 1,600 kW (2,100 hp) or 2 MVA with capacity to handle inrush currents	The existing C8-L6 line is adequate for loads up to 10 MVA. Enough VSDs will be present in building 241-AZ-156 to run two sets of mixer and transfer pumps. However, the transformer only has capacity to run one set. Therefore, If more than two mixer pumps are to be run simultaneously in the AN/AZ farms, the transformer will have to be replaced.	No	Refer to Analysis in Appendix F, Section F.3.1. If more than two mixer pumps are to be run simultaneously in the AN/AZ farms, the transformer will have to be replaced.	In-rush current capacity is not expected to be an issue due to the "soft" starts to be performed via the VFD's.

Table B-1. Comparison of Process Needs to Existing and Planned Equipment for Utilities in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
9.P1.2. Provide transfer pumps with a water addition feature that will provide slurry dilution capability at the pump suction. The needed dilution water flow rate is 265 L/min (70 gal/min) (TBR). Pipeline transfer parameters of interest include pressure drop and solids deposition. The quantity of diluent is determined on a transfer by transfer basis such that pipeline operating pressures are not exceeded and calculated critical settling velocities are < 1.2 m/sec (4 ft/sec).	Raw water system will feed the AZ farm.	Yes	Per HNF-1507, Appendix D, Section D.2.13.	Raw Water System is capable of providing water to the Diluent systems. The adequacy of the raw water flow rate must be verified at the design review.
9.P4.1. Provide a diluent system the transfer lines with raw or inhibited water at 530 L/min (140 gal/min) (TBR).	Raw water system will feed the AZ farm.	Yes	Per HNF-1507, Appendix D, Section D.2.13.	Raw Water System is capable of providing water to the Diluent systems. The adequacy of the raw water flow rate must be verified at the design review.
9.P4.3. Flush transfer lines with water volumes equivalent to 1.5 times the transfer line internal volume.	Raw water system will feed the AZ farm.	Yes	Per HNF-1507, Appendix D, Section D.2.13.	Raw Water System is capable of providing water to the Diluent systems. The adequacy of the raw water flow rate must be verified at the design review.

General Notes

1. It is understood that several systems will require electrical utility support, i.e., monitoring and/or control systems, the ventilation systems, etc. An enabling assumption for this evaluation is that the existing electrical system is capable of meeting the requirements for these systems, i.e., low demand systems. The point is further made here that a low demand system is a system with an order of magnitude less power requirements than a 300 HP pumps or large scale ventilation systems with large blowers, chillers, and associated support systems.

Table B-2. Comparison of Safety Requirements to Existing And Planned Equipment For Utilities in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
1.S5.1. Service water pressure detection systems that are physically connected to an active waste transfer pump not under administrative lock shall be operable.	Equipment in place, planned or to be covered by procedure.	Yes	Per HNF-IP-0842, Volume IV, Section 5.4, a USQ review will be required for all, ECN's, New Design Media, operating procedures, or changes to the facility, to ensure the TSR requirements are met.	
8.S3.4 Tank 241-AZ-101 air lift circulation must be operable when waste solution temperature is >93 °C (200 °F) and when sludge temperature is >110 °C (230 °F). *Note: it is assumed that this will also be applicable to tank 241-AZ-102.*	Equipment in place.	Yes	Documented on H-2-68335. Per HNF-IP-0842, Volume IV, Section 5.4, a USQ review will be required for all, ECN's, New Design Media, operating procedures, or changes to the facility, to ensure the TSR requirements are met	
8.S2.1. Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	Equipment in place	Yes	Documented on H-2-68335. Per HNF-IP-0842, Volume IV, Section 5.4, a USQ review will be required for all, ECN's, New Design Media, operating procedures, or changes to the facility, to ensure the TSR requirements are met.	
9.S1.2. Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	Equipment in place.	Yes	Documented on H-2-68335. Per HNF-IP-0842, Volume IV, Section 5.4, a USQ review will be required for all, ECN's, New Design Media, operating procedures, or changes to the facility, to ensure the TSR requirements are met.	

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APPENDIX C

INSTRUMENTATION, MONITORING, AND CONTROL PROCESS NEEDS AND ASSESSMENT

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APPENDIX C

INSTRUMENTATION, MONITORING, AND CONTROL PROCESS NEEDS AND ASSESSMENT

Operations supporting waste feed delivery must be monitored and controlled to stay within an approved authorization safety basis as well as to deliver waste feed within the constraints established by the Phase 1 privatization contract. Successful waste retrieval and delivery of the proper composition waste feed to the private contractor within schedule requires that in-tank processing and transfers be effectively controlled. Development and implementation of a successful process monitoring and control system requires that overall process operational needs be clearly defined.

C.1 PROCESS NEEDS

Process control parameters for process operations, to maintain safe operation and to respond to off-normal conditions are presented in Tables C-1, C-2 and C-3 respectively. Table C-4 identifies manipulated parameter(s) and monitored variable(s) for each control parameter identified in Tables C-1 through C-3. Table C-5 identifies monitoring and control instrumentation based on the monitoring methods established in Table C-4.

C.2 EXISTING AND PLANNED MONITORING, INSTRUMENTATION AND CONTROL EQUIPMENT

Table C-6 identifies the existing and planned monitoring, instrumentation and control equipment for 241-AN tank farm. The project responsible for placement of the equipment in the tank farm is also identified for that monitoring, instrumentation and control equipment which is planned.

C.3 COMPARISON OF EXISTING AND PLANNED MONITORING, INSTRUMENTATION AND CONTROL EQUIPMENT TO PROCESS NEEDS

Table C-7 compares the process monitoring and control needs established in Tables C-1 through C-5 to the existing and planned monitoring, instrumentation and control equipment identified in Table C-6. Table C-7 identifies whether the existing and planned equipment is adequate to meet the process needs for monitoring and control and also establishes the technical basis for whether or not the existing or planned equipment is adequate.

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
1. Safe Storage	See Table 4.2	See Table 4.2	See Table 4.2	
2. Degas Feed (This process step/need applies only to flammable gas watch list tanks 241-AN-103, 241-AN-104 and 241-AN-105, 241-AW-101, 241-SY-101, and 241-SY-103)	P1. Remove trapped flammable gases from waste prior to transfer to eliminate or reduce probability of occurrence of a gas release event.	1. Reserved (None)	Process step Not Applicable to 241-AZ Tanks. (N/A)	
	P2. Control rate of gas release from flammable gas watch list tanks.	1. Reserved (None)	N/A	
3. Separate Solids and Liquids	P1. Provide LAW feed to the private contractor within the contract envelope limits for insoluble solids.	1. Reserved (None)	N/A	
4. Dissolve Solids	P1. Dissolve soluble precipitated salts in selected DSTs. Selected DSTs are 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, 241-SY-101, and 241-SY-103.	1. Reserved (None)	N/A	
	P2. Allow operation of equipment (bottom thermocouples, mixer pumps, decant pumps, slurry transfer pumps)	1. Reserved (See 5B.P2.1)	See 5B.P2.1	
	P3. Retrieve waste from multiple tanks as needed to support waste feed delivery schedule.	1. Reserved (See 5B.P4.1)	See 5B.P4.1	

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
5A.Mobilize Solids	P1. Transfer solid particles from a static settled state solid phase to a dynamic state. (If solids transferred to AZ farm allowed to settle)	1. Mobilize >90% of the solids initially in 241-AZ-101, >60% of the solids initially in 241-AZ-102, and >99% of the solids transferred to these tanks from 241-AY-102.	Waste Density (% solids)	
	P2. Reserved			
	P3. Prevent components from exceeding operating parameters for the system	1. Equipment used to suspend or mobilize waste shall be able to operate under both normal startup and operation conditions (Note: for the currently planned system - Prevent cavitation of the mixer pump during normal startup and operation conditions).	Pump rotational speed, primary tank level, waste temperature, waste density, pump/motor vibration, vapor space pressure	
		2. Reserved		
		3. Control excursions into unplanned operations scenarios for initial system start up and subsequent operation. (Note: for the currently planned system - provide mixer pumps with a VFD capable of operating the pump from a minimum speed to full speed operation.	VFD system, pump RPM, vapor space pressure	Note that the minimum operating speed is 58% due to seal design.
		4. Provide in-tank components which can withstand forces imparted by solids mobilization and suspension equipment and remain operable and retrievable from the DST. (Note: for the currently planned system - Provide (or replace) in-tank components which can withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST)	In-tank camera with controls with air or nitrogen purge pressure/flow	

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
5A. Mobilize Solids (cont.)		5. Provide solids mobilization and suspension equipment which will not damage the tank structure during normal and/or off-normal operation. (Note: for the currently planned system - Provide mixer pumps which will not damage the tank structure during normal and/or off-normal operation.)	In-tank camera with controls with air or nitrogen purge pressure/flow	
		6. Monitor the rate of operation of equipment used to effect solids mobilization and suspension. (Note: for the currently planned system - Provide, at a minimum, the following mixer pump instrumentation: remote readout of pump motor amperage, shaft rotational speed, and nozzle orientation.)	Motor current, RPM, nozzle orientation	
5B. Suspend Solids	P1. Suspend mobilized solid particles in the liquid phase. (Note: for currently planned system - Mixer pump operation should mix liquids and suspend mobilized solids uniformly throughout the waste solution.)	1.Reserved	Not Applicable to 241-AZ Tanks	
		2. Mix tank contents to provide <TBD% variability of suspended HLW solids concentrations over the full depth prior to sampling and prior to beginning each feed transfer.	Primary tank waste density (% solids)	
	P2. Add diluent to allow operation of equipment	1. Provide capability for addition of 379 m^3 (100,000 gal) of inhibited water to 241-AZ-101 and 241-AZ-102 for each of the final two slurry transfers to the Privatization Contractor. The inhibited water shall meet the minimum corrosion specifications of 0.01<u>M</u> OH^- and 0.011<u>M</u> NO_2^-.	Diluent volume, diluent chemistry, waste level, waste temperature.	
	P3. Reserved.			

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
5B. Suspend Solids (cont.)	P4. Retrieve waste from multiple tanks as needed to support waste feed delivery schedule.	1. Provide for the independent operation of one set of mixer pumps in each of four 200 East Area DST farms and one transfer pump in a 200 East Area DST farm. Provide control systems and electrical distribution systems which can support the independent operation of retrieval equipment in each of the four 200 East Area DST farms and one transfer system in a 200 East area DST farm.	None--operational control required but see note for automatic control limitations imposed on VFD system for mixer pumps.	Note that Project W-211 Initial Tank Retrieval Systems Description of Operations for AP-102/104 (Rev. D, 6/1/98) limits the simultaneous operation of 2 mixer pumps to 1 @ 100% and 1 @ 60% due to size of the electrical transformer.
6. Sample Waste	P1. Ensure compatibility between sending and receiving tanks	1. Provide capability for taking multiple representative grab samples of the waste from one or more risers. Waste compatibility testing is performed per existing DQOs.	Grab sampling system for primary tank.	
	P2. Confirm waste composition and inventory within contract specifications	1.Reserved		
		2. The total sample volume, will meet the sample volume needs for: analysis of the tank waste to support feed certification, a sample to BNFL, and archive sample material. The tank waste sample provided to BNFL will contain at least 200 grams of solids. Tank waste conditions such as temperature and tank volume will be identified at the time of sampling. Samples of each HLW feed tank will be provided to the privatization contractor at least 30 days prior to the first transfer of such waste to the contractor's feed tank and no later than 5 days after sampling of the feed batch.	Grab sampling system.	

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
6. Sample Waste (cont.)		3. The HLW tank waste sampling method (core sampling or grab sample techniques) will be established for each tank waste based upon the waste characteristics and capability of the system. Immediately following the shutdown of the mixer pump, approximately equal volume grab samples of waste material will be obtained from every 0.61 m (2 ft) of waste height from below a single riser for a grab sampling technique. (For a core sampling technique a core the entire height of the tank waste will be obtained).	Grab sampling system.	
7. Transfer Supernate from Tank	P1. Avoid solids accumulation which could plug the transfer line. Avoid solids precipitation during transfer due to cooling or dilution	1. Reserved (None)		
	P2. Remove targeted waste volumes/levels.	1. Reserved (None)		
	P3. Prevent components from exceeding operating parameters for the system.	1. Reserved (None)		
	P4. Capability to flush the transfer lines with inhibited water.	1. Reserved (None)		
8. Receive Supernate into Tank	P1. Do not overfill tank.	1. Reserved (None)		
9. Transfer Solids Slurry from Tank	P1. Avoid solids accumulation which could plug the transfer line.	1. Provide transfer system capable of achieving a waste transfer velocity of 1.8 to 2.7 m/s (6 to 9 ft/sec).	Slurry flow rate	Need to correlate flow rate with transfer piping cross-sectional area.
		2. Provide transfer pumps with a water addition feature that will provide slurry dilution capability at the pump suction. The needed dilution water flow rate is 530 L/min (140 gal/min).	Diluent pressure, diluent flow rate, Transfer piping pressure, transfer piping flow rate, transfer piping differential pressure (source tank to receiver), slurry viscosity, slurry density	

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
9. Transfer Solids Slurry from Tank (cont.)	P2. Remove targeted waste volumes/levels.	1. Determine total HLW solids mass (expressed as non-volatile oxides) transferred to the Privatization Vendor to within a variability of TBD%.	Sampling system (slurry characterization)	
	P3. Prevent components from exceeding operating parameters for the system	1. In normal operation, maintain the transfer system pressure drop below the transfer line operating pressure. The maximum line operating pressure can vary between, 16.8 to 28.6 kPa (230 to 400 psi) depending on the transfer line.	Transfer piping differential pressure (source to receiver)	
		2. Transfer system components within the tanks shall withstand external forces imparted by other equipment. (Note: for currently planned system - In tanks containing mixer pumps, provide slurry transfer pumps which can be operated during mixer pump operation and withstand forces imparted by full speed mixer pump operation and remain operable and retrievable from the DST	None	Note that present design (Project W-211) does not allow mixer pumps to operate unless transfer suction bell is fully raised.
		3. Provide transfer system components capable of transferring waste with a density as high as 1.4 g/ml.	Waste density	Requirements to be satisfied by transfer system design.
		4. Provide transfer system components capable of handling wastes with a pH of 7 or greater.	None	Requirements to be satisfied by transfer system design.
		5. Provide a transfer system which prevents the occurrence of water hammer resulting from reconfiguration of the system during the transfer.	None	Requirements to be satisfied by transfer system design.
		6. Transfer system equipment shall function during normal startup and operation conditions. Net positive suction head required should not exceed net positive suction head available at most restrictive expected operating conditions	Primary tank waste level, waste temperature, waste density, vapor space pressure, transfer pump RPM, pump/motor vibration.	

Table C-1. Process Control Parameters for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Process step	Qualitative process need	Quantitative tank-specific process need	Control parameter(s)	Comments/issues
9. Transfer Solids Slurry from Tank (cont.)	P4. Capability to flush the transfer lines with inhibited water.	1. Provide a diluent system to flush the transfer lines with inhibited water at 530 L/min (140 gal/min).	Transfer pump discharge pressure, flow, flush water chemistry	
		2. Flush transfer lines with water volumes equivalent to 1.5 times the transfer line internal volume.	Transfer Piping flush water volume.	
10. Receive Solids Slurry into Tank	P1. Do not overfill tank	1. Provide tank level monitoring and alarm systems	Primary waste level (receiver tank)	
	P2. Minimize generation of aerosols in 241-AY and 241-AZ Tank Farms	1. In 241-AZ and 241-AY tanks, provide a drop leg or other method of discharging liquid beneath tank waste surface.	None, part of mechanical system design	

Table C-2. Safety Control Parameters for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Flowsheet process step	Qualitative process safety objective	Quantitative tank-specific process safety requirement	Control parameters	Comments/issues
1. Safe Storage	S1. Manage flammable gas hazards	1. Reserved	Not Applicable for 241-AZ Tanks	
		2. Manage tanks AZ-101 and AZ-102 as Facility Group 2 assignments.	Hydrogen gas monitoring, vapor space pressure, annulus leak detection (air stream)	Per the BIO 5.3.2.14, flammable gas can be monitored by sampling for hydrogen only, with an alarm at 7500 ppmv.
		3. Maintain flammable gases concentrations no greater than 25% of the lower flammability limit	Hydrogen gas monitoring, vapor space pressure	
	S2. Manage potential ignition sources that can initiate a fire or flammable gas deflagration.	1. Reserved	Not Applicable for 241-AZ Tanks	
		2. Flammable gas ignition source controls for Tanks AZ-101 & AZ-102 are Facility Group 2 requirements.	Hydrogen gas monitoring, vapor space pressure	
		3. An active primary ventilation system shall be operable for all DSTs and AWTs	Ventilation stack flow rate, vapor space pressure	
	S3. Monitor flammable gas concentrations to prevent deflagration	1.Reserved	Monitoring required since AZ-101 tanks are a facility Group 2 tanks.	
	S4. Provide operable transfer system covers	1. Transfer system covers associated with structures that are physically connected to an active waste transfer pump not under administrative lock or under the control of AC 5.22, "Transfer System Cover Removal Controls" shall be operable.	None	
	S5. Provide service water pressure detection	1. Service water pressure detection systems that are physically connected to an active waste transfer pump not under administrative lock shall be operable.	Diluent pressure, raw water pressure	

Table C-2. Safety Control Parameters for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Flowsheet process step	Qualitative process safety objective	Quantitative tank-specific process safety requirement	Control parameters	Comments/issues
1. Safe Storage (cont.)	S6. Provide transfer leak detection	1. Leak detection in all process pits, diversion boxes, vault pits, and cleanout boxes physically connected to an active waste transfer pump that is not under administrative lock shall be operable.	Tank/diversion box level, encasement conductivity probe	
	S7. Provide ventilation stack continuous air monitor (CAM) interlock systems	1. Primary tank ventilation stack CAM interlock systems shall be operable when active ventilation is operating.	Radiation detector (exhaust stack), HEPA filter differential pressure	
	S8. Provide tank ventilation	1. An active primary tank ventilation system for DSTs and AWF tanks shall be operable.	Ventilation stack flow rate, vapor space pressure	
	S9. Provide primary tank leak detection	1. Either the annulus conductivity probe system or the annulus continuous air monitor system shall be operable for DSTs and AWF tanks.	Annulus conductivity sensor , ventilation stack flow rate, radiation detector (exhaust stack)	
	S10. Control tank waste temperature	1. Tank waste temperature shall be either: ≤90 °C (195 °F) in all levels of the waste; or ≤90 °C (195 °F) in the top 4.6 m (15 ft) of the waste and ≤102 °C (215 °F) in the waste below 4.6 m (15 ft).	Waste temperature	
		2. Waste temperature shall not exceed 121 °C (250 °F).	Waste temperature	
	S11. Prevent primary tank overfilling	1. Provide instrumentation, monitoring and controls for service water to avoid overfilling a waste tank in the event of a water line break.	Service water flow totalizer , primary tank level	Flow totalizer specified by BIO (pg. 5.4-58)
	S12. Prevent subsurface release of radioactive materials due to leaks in multiple tanks.	1. Provide primary tank leak detection, tank level monitoring, and temperature monitoring, and transfer controls on waste pH.	Primary tank temperature monitoring, primary tank leak detection, primary tank level monitoring system.	Instrumentation specified by BIO (pg. 5.4-153)
4. Add Diluent to Tank	S1. Prevent contamination of service water systems	1. Prevent backflow of waste from active waste transfer pump into service water systems that are physically connected during transfer	Diluent/raw water differential pressure, radiation detection system	

Table C-2. Safety Control Parameters for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Flowsheet process step	Qualitative process safety objective	Quantitative tank-specific process safety requirement	Control parameters	Comments/issues
5. Mix Tank Contents	S1. Control tank waste temperature	1. Tank waste temperature shall be either: ≤91 °C (195 °F) in all levels of the waste; or ≤91 C (195 °F) in the top 4.6 m (15 ft) of the waste and ≤102 °C (215 °F) in the waste below 4.6 m (15 ft).	Waste temperature	
		2. Temperature changeover time for solutions in tanks shall be ≤5.6 °C/hr (10 °F/hr (< 125 °F) or ≤11 °C/day (20 °F /day (≥125 °F)	Waste temperature, temperature trend recorder	
		3. Temperature gradients of solution in tanks shall be ≤100 °C/ft (55 °F/ft) within the solution and at the solution/vapor interface.	Waste temperature	Need to determine the vertical and horizontal placement of temperature sensors to meet the gradient requirement
		4. Tank 241-AZ-101 air lift circulation must be operable when waste solution temperature is >93 °C (200 °F) and when sludge temperature is >110 °C (230 °F).	Waste temperature, circulator air pressure and air flow	Note: it is assumed that this will also be applicable to tank 241-AZ-102
	S2.Monitor for leaks or line misroutings	1.Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	Instrument air pressure, instrument air flow rate	
9. Transfer Solids Slurry from Tank	S1. Monitor for leaks or line misroutings	1. Perform material balance calculations during each waste transfer. Calculations shall be performed at 30 and 60 minutes following waste transfer initiation and every 2 hours thereafter until the transfer is complete (safety constraint)	Waste mass flow meter	
		2.Provide instrument air to weight factor leak detection systems at an appropriate flow rate and pressure.	Instrument air flow rate, instrument air pressure	

Table C-2. Safety Control Parameters for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Flowsheet process step	Qualitative process safety objective	Quantitative tank-specific process safety requirement	Control parameters	Comments/issues
9. Transfer Solids Slurry from Tank (cont)	S2. Prevent contamination of service water systems	1. Prevent backflow of waste from active waste transfer pump into service water systems that are physically connected during transfer	Diluent/raw water differential pressure, radiation detection system	
	S3. Detect subsurface leaks that remain subsurface	1. Transfer leak detection systems in systems and structures connected to a waste transfer pump and pipe-in-pipe encasements shall be operable	Tank/diversion box level, encasement conductivity probe	
	S4. Mitigate transfer spray leak	1. Ventilation stack CAM interlock systems shall be operable	Exhaust stack radiation detector, HEPA filter differential pressure	
10. Receive Solids Slurry into Tank	S1. Control tank waste temperature	1. Tank waste temperature shall be either: ≤91 °C (195 °F) in all levels of the waste; or ≤91 °C (195 °F) in the top 4.6 m (15 ft) of the waste and ≤102 °C (215 °F) in the waste below 4.6 m (15 ft).	Waste temperature, mixer pump controls (speed, orientation), air lift circulator air supply pressure & flow	

Table C-3. Off-normal Occurrence Control Parameters for 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Flowsheet process step	Process need	Postulated off-normal occurrence	Control parameter(s) (from Tables C-1 and C-2)	Additional control parameter(s) needed	Comments/issues
1. Safe Storage	S1. Manage flammable gas hazards	flammable gas concentration in vapor space exceeds requirements	hydrogen gas monitoring, vapor space pressure, ventilation flow rate	None	BIO uses Administrative Controls for this situation (e.g. AC 5.10, 5.12, 5.14)
	S2. Manage potential ignition sources that can initiate a fire or flammable gas deflagration.				
	S3. Monitor flammable gas concentrations to prevent deflagration	See S1 above.			
	S4. Provide operable transfer system covers				
	S5. Provide service water pressure detection	pressure switch fails to activate alarm/interlock	diluent pressure, raw water pressure	diluent/raw water radiation detector	
	S6. Provide transfer leak detection	indication received of a leak in transfer line or diversion box	Tank/diversion box level, encasement conductivity probe		
	S6. Provide ventilation stack continuous air monitor (CAM) interlock systems	CAM failure	radiation detector (exhaust stack), HEPA filter differential pressure	CAM failure alarm	
	S7. Provide tank ventilation	ventilation system failure	vent stack flow, vapor space pressure	ventilation system failure/trouble alarms	
	S8. Provide primary tank leak detection				
	S9. Control tank waste temperature				

Table C-3. Off-normal Occurrence Control Parameters for 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Flowsheet process step	Process need	Postulated off-normal occurrence	Control parameter(s) (from Tables C-1 and C-2)	Additional control parameter(s) needed	Comments/issues
1. Safe Storage (cont.)	S10. Prevent primary tank overfilling	service water flow totalizer failure	flow totalizer, primary tank level	service water low and high flow alarms	
	S11. Prevent subsurface release of radioactive materials due to leaks in multiple tanks.				
2. Degas Feed	Process step not applicable to 241-AZ tanks				
3. Settle Solids	Process step not applicable to 241-AZ tanks				
4. Add Diluent to Tank	P1. Add diluent to dissolve soluble precipitated salts in selected DSTs. Specifically, tanks 241-AN-103, AN-104, AN-105, AW-101, SY-101, and SY-103.	Not Applicable to 241-AZ Tanks			
	P2. Add diluent to allow operation of equipment (bottom thermocouples, mixer pumps, decant pumps, slurry transfer pumps)				
	P3. Add diluent to adjust waste composition to meet tank corrosion specifications	Not Applicable to 241-AZ Tanks			
5. Mix Tank Contents	S1. Control tank waste temperature				

Table C-3. Off-normal Occurrence Control Parameters for 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Flowsheet process step	Process need	Postulated off-normal occurrence	Control parameter(s) (from Tables C-1 and C-2)	Additional control parameter(s) needed	Comments/issues
5. Mix Tank Contents (cont.)	S2. Any instrument important to process control requiring instrument air shall receive the air at an appropriate flow rate and pressure	instrument air supply to air lift circulators fails	instrument air supply pressure and flow	tank waste temperature, mixer pump controls	
	P1. Transfer solid particles from settled solid phase to suspended solids in a liquid phase				
	P2. Mixer pump operation should mix liquids and suspend mobilized solids uniformly throughout the waste solution.				
	P3. Components should not exceed operating parameters for the system	mixer pump cavitation detected	pump speed, tank level, waste temperature and density, pump/motor vibration, vapor space pressure	none	
	P4. Electrical distribution system should provide for the simultaneous operation of 9 mixer pumps	loss of power to one or more mixer pumps	none	none	
6. Sample Waste	P1. Ensure compatibility between sending and receiving tanks				
	P2. Confirm waste composition and inventory within contract specifications	Not applicable to 241-AZ tanks			
7. Transfer Liquid from Tank	Not Applicable to 241-AZ Tanks				

Table C-3. Off-normal Occurrence Control Parameters for 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Flowsheet process step	Process need	Postulated off-normal occurrence	Control parameter(s) (from Tables C-1 and C-2)	Additional control parameter(s) needed	Comments/issues
8. Receive Liquid into Tank	Not Applicable to 241-AZ Tanks				
9. Transfer Solids Slurry from Tank	S1. Monitor for leaks or line misroutings	indication received of a leak in transfer line or diversion boxes	waste mass flowmeter, encasement/diversion box leak detectors	interlock to trip transfer pump	
	S2. Any instrument important to process control requiring instrument air shall receive the air at an appropriate flow rate and pressure.				
	P1. Avoid solids accumulation which could plug the transfer line.	Transfer line plugs to allow less than required flow rate, pressure drop, or velocity	transfer piping diff. pressure, pressure, flow rate; diluent or flush pressure, flow rate	transfer piping flush water pressure, flow rate	
	P2. Transfer system should be capable of removing targeted waste volume/levels.	Transfer pump trip during transfer (e.g. from master pump shutdown signal)	flush water pressure, flow	none	
	P3. Components should not exceed operating parameters for the system				
	P4. The transfer system should have capability to flush transfer lines with raw or inhibited water.				
10. Receive Solids Slurry into Tank	P1. Do not overfill tank.				
	P2. Minimize generation of aerosols in 241-AY and 241-AZ Tank Farms				

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
1. Safe Storage	1.1 hydrogen gas monitoring	primary tank ventilation air flow, mixer and transfer pump operation	hydrogen gas (vapor space and pump pits)	hydrogen analyzer (continuous, on-line sampling)	grab sample	
	1.2 vapor space pressure	ventilation air flow	vapor space pressure (vacuum)	pressure transmitter (DP or absolute) with remote indication/alarm	local pressure gage	
	1.3 ventilation stack air flow	fan speed, damper position	stack air flow rate	stack isokinetic probe/control system	pitot tube flow transmitter	
	1.4 diluent pressure	pump speed	diluent pressure	pressure transmitter with remote switch and indication	local pressure gage	
	1.5 raw water pressure	pump speed, pressure control valve	raw water pressure	pressure transmitter with remote switch and indication	local pressure gage	
	1.6 exhaust stack radiation	none	exhaust stack radiation	CAM with interlock to exhaust fan		
	1.7 HEPA filter differential pressure	none	differential pressure across HEPA filter	differential pressure transmitter with local/remote indication and interlock with exhaust fan		
	1.8 annulus leak detector	none	liquid level in bottom of DST (outside tank)	conductivity probes set at proper elevations	level transmitter with remote indication/alarm	
	1.9 primary tank waste temperature	diluent volume	waste temperature	RTDs at elevations to give temperature gradients at various tank levels	Thermocouples at elevations to give temperature gradients at various tank levels	RTDs will provide ± 1F. accuracy; T/Cs will provide ± 2.8F. Elevations and spatial distribution of temperature sensors need to be determined to give the needed temperature profiles.
	1.10 diluent and raw water volume	diluent and raw water flow	diluent and raw water volume	diluent and raw water flow totalizer	flow transmitter with indicator plus stopwatch	

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
1. Safe Storage (cont)	1.11 primary tank waste level	diluent and raw water volume	tank level	ENRAF™ level system	level sensors at fixed locations, ultrasonic system	May not obtain accurate level data when mixer pump is in operation and ENRAF™ is in "dip" mode
	1.12 waste temperature trending	diluent volume	waste temperature trending	trend recorder connected to temperature monitoring system (see CP 1.9)		
	1.13 air lift circulator air pressure	air pressure and flow	air pressure and flow	pressure and flow transmitters with local and remote indication (instrument air system)	local gage and rotameter	
2. Degas Feed	Process step not applicable to 241-AZ Tanks					
3. Separate Solids and Liquids	Process step not applicable to 241-AZ Tanks					
4. Dissolve Solids	4.1 diluent volume	See CP 1.10				Although not applicable to AZ Farm, control parameters apply to diluent addition of Process Step 5B.
	4.2 diluent chemistry	chemical additives	diluent chemistry	on-line analyzer (continuous)	grab samples with remote analysis	
	4.3 primary tank waste level	See CP 1.11				
	4.4 primary tank waste temperature	See CP 1.9				
	4.5 diluent pressure	See CP 1.4				
	4.6 diluent flow rate	diluent water pump speed	diluent flow rate	flow totalizer with remote flow indicator	local flow indicator (e.g., rotameter)	

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
4. Dissolve Solids (cont.)	4.7 slurry density	diluent flow/volume	slurry density	ENRAF™ displacer, URSILLA system	grab sample with remote analysis	ENRAF™ will not be operable when mixer pumps are in operation
	4.8 slurry viscosity	diluent volume	slurry viscosity	grab sample with remote analysis		
5A Mobilize Solids & 5B Suspend Solids	5.1 mixer pump rotational speed (prevention of cavitation)	motor current (pump speed)	pump rotational speed	mixer pump VFD	None	U_oD value is a design limit for the mixer pump
	5.2 primary tank waste level	See CP 1.11				
	5.3 primary tank waste temperature	See CP 1.9				
	5.4 primary tank waste density	See CP 4.7				ENRAF™ not operable when mixer pump is in operation
	5.5 mixer pump/motor vibration	motor current (pump speed), waste level (NPSH)	pump speed	accelerometer with remote indication at VFD control station	None	
	5.6 direction of mixer pump rotation	none	direction of pump rotation	No monitoring-prevent by design features of mixer pump and pre-operational testing		Need to investigate if this process need is valid
	5.7 mixer pump rotational speed (not to exceed velocity-diameter product)	See CP 5.1				
	5.8 diluent volume (primary tank)	See CP 1.10				
	5.9 mixer pump rotational speed (range of 25-100%)	See CP 5.1				Note that minimum operating speed is 58% due to seal design

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
5A Mobilize Solids & 5B Suspend Solids (cont.)	5.10 visual observation of in-tank equipment during mixer pump operation	none	visual observation	In-tank camera with controls and air or nitrogen purge pressure and flow	acoustic emission sensors	
	5.11 mixer pump discharge nozzle orientation	nozzle orientation	nozzle orientation	turntable drive position indication (part of mixer pump VFD system)		
6. Sample Waste	6.1 grab sampling system for primary tank					Need remote analysis capability
7. Transfer Liquid from Tank	Process step not applicable to 241-AZ tanks					
8. Receive Liquid into Tank	Process step not applicable to 241-AZ tanks					
9. Transfer Solids Slurry from Tank	9.1 slurry flow rate	transfer pump speed	slurry flow rate	mass flow meter		
	9.2 transfer piping diluent pressure	diluent pump speed, control valve	diluent pressure	pressure transmitter with remote indication	local pressure gage	
	9.3 transfer piping diluent flow	diluent pump speed, control valve	diluent flow	flow totalizer	flow indicator (transmitter or rotameter) and stopwatch	
	9.4 transfer piping differential pressure (between source tk. and receiver tk.)	Slurry flow rate, diluent volume	differential pressure	pressure transmitter at each end of transfer with remote indicator and comparator	visual comparison of pressure readings	Assumption: Privatization contractor controls instruments at receive tank--remote indication
	9.5 transfer piping pressure	transfer pump speed	slurry pressure	pressure transmitter with remote indication	local pressure gage	
	9.6 transfer piping flow rate	See CP 9.1				

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
9. Transfer Solids Slurry from Tank (cont.)	9.7 slurry viscosity	diluent volume, flow	slurry viscosity	grab sampler	on-line analyzer	
	9.8 slurry density	diluent volume, flow	slurry density	grab sampler	on-line analyzer	
	9.9 sampling system for slurry characterization		slurry chemistry	grab sampler	on-line analyzer	
	9.10 transfer pump discharge pressure	pump speed	discharge pressure	pressure transmitter with remote indication	local pressure gage	
	9.11 primary tank waste level	See CP 1.11				
	9.12 primary tank waste temperature	See CP 1.9				
	9.13 slurry density	See CP 4.7				
	9.14 primary tank vapor space pressure	See CP 1.2				
	9.15 transfer pump rotational speed	pump speed	pump speed	pump VFD controls and indication		
	9.16 transfer pump/motor vibration	pump speed, NPSH	vibration	local accelerometers with remote indication		
	9.17 transfer pump direction of rotation	pump on/off, speed	rotational direction	transfer pump VFD		
	9.18 transfer pump motor current	pump speed	motor current	VFD controls		
	9.19 transfer pump motor bearings and windings temperature	pump speed	motor winding and bearing temperature	T/C or RTD in motor, indication with VFD display		
	9.20 transfer piping flush water flow	flush water pump speed	flush water flow	flow totalizer with remote indication	flow indicator (transmitter or rotameter) and stopwatch	
	9.21 transfer piping flush water chemistry	chemical additives	flush water chemistry	on-line sampler	grab sample with remote analysis	

Table C-4. Monitoring Methods for 241-AZ Tank Farm Supporting Phase 1 Feed Delivery.

Flowsheet process step	Control parameter(s)	Manipulated parameter(s)	Monitored variable(s)	Expected monitoring and control approach	Alternative M&C approaches considered	Comments/issues
9. Transfer Solids Slurry from Tank (cont)	9.22 transfer piping flush water volume	See CP 9.20				
10. Receive Solids Slurry into Tank	10.1 tank waste level	transfer volume, diluent volume	tank waste level	ENRAF™ system		
	10.2 tank waste temperature	See CP 1.9				
	10.3 mixer pump speed controls (speed, orientation)	See CP 5.1 and 5.6				
	10.4 air lift circulator air supply	See CP 1.13				

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation	Range	Setpoints functions				Comment/issue
			HiHi	Hi	Lo	LoLo	
AZ-101	hydrogen analyzer (continuous, on-line sampling)	CH1 0-10% H2 CH2 0-1% H2	Not required	Required	Low or FAIL Required	Not required	Existing system has Hi and Fail alarms
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)	-25.4 to + 12.7 cm (-10 to +5 in. WG)	Required	Required	Required	Required	Existing PIT is set for ___ to ___ cm (-6 to +4 in. WG). All alarms are generated in Micon unit.
	stack isokinetic probe/control system (exhaust flow)	Stack Flow: 0 to 24.7 m/min (0 to 871 scfm) Sample Flow: 0 to 57 L/min (0 to 2 scfm)		Required	Required		
	pressure transmitter with remote switch and indication (tank diluent)	TBD		Required			
	pressure transmitter with remote switch and indication (raw water)	1.01 to 7.81 kPa (0 to 100 psig)					
	CAM with interlock to exhaust fan	0 to 10,000 cps		Required	Low or Fail Required		
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	TBD		Required	Required	Required	
	conductivity probes set at proper elevations (annulus leak detectors)	Radiation 0 to 10,000 cps Leak 2.54 cm (1 in.) and 25.4 cm (10 in.) in leak detection pit		Required		Required for Rad Mon Fail.	Existing instrumentation consists of WFT101-1 and 101-2. Also TE-101-AZ-27 monitors temperature in the pit.

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation	Range	Setpoints functions				Comment/issue
			HiHi	Hi	Lo	LoLo	
AZ-101 (cont.)	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	TBD	Required	Required	Required		To provide temperature gradient information to protect tank integrity
	raw water flow totalizer (primary tank)	0-TBD L	Not required.	Required	Required		
	ENRAF™ level system (primary tk.)	0 to 9.25 m (0 to 364 in.)	Required	Required	Required		
	trend recorder connected to waste temperature monitoring system	0-TBD		Delta T between set of TEs (TBD)			
	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators) and air lift circulator temperature indication.	1.01 to 3.42 kPa (0 to 35 psig) and 566 L/min (20 scfm)		Temp Hi required	Press-Low Flow-Low		
	on-line analyzer (continuous) for diluent water chemistry	pH TBD-TBD, Conductivity TBD-TBD micromho, Viscosity TBE-TBD cP		Required			
	flow totalizer with remote flow indicator (diluent)	0 to 454 m3 (0 to 120,000 gal)		Required to indicate approaching set value.			
	ENRAF™ system; URSILLA system (primary tank density)			Required			
	grab sample with remote analysis (slurry viscosity) TBD if required.	TBD					

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation	Range	Setpoints functions				Comment/issue
			HiHi	Hi	Lo	LoLo	
AZ-101 (cont.)	mixer pump VFD (rotational speed)	0-TBD rpm		Required	Required - pump/motor protection		
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration) TBD if required.	0-TBD mils		Required- pump/motor protection			
	In-tank camera with controls and air or nitrogen purge pressure and flow	0 to 85 L/min (0 to 3 scfm) pressure 1.01 to 5.15 kPa (0 to 60 psig)			Required		
	turntable drive position indication	0-180 °					
	mass flow meter (slurry transfer)	0-TBD kg/hr		Required-to indicate approaching the set value.			
	pressure transmitter with remote indication (transfer piping diluent)	1.01 to 32.0 kPa (0 to 450 psig)		Required-			
	flow totalizer (transfer diluent)			Required to indicate approaching set value			
	pressure transmitter at each end of transfer piping with remote indicator and comparator	1.01 to TBD kPa		Required-line protection & to indicate line plug			
	pressure transmitter with remote indication (transfer piping)	1.01 to TBD kPa		Required-line protection			
	grab sampler (slurry transfer)	N/A					

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation		Range	Setpoints functions				Comment/issue
				HiHi	Hi	Lo	LoLo	
AZ-101 (cont.)	pressure transmitter with remote indication (transfer pump discharge)		1.01 to 32.0 kPa (0 to 450 psig)					
	transfer pump VFD controls and indication (speed)		TBD					
	local accelerometers with remote indication (transfer pump/motor vibration) TBD if required.		TBD					
	transfer pump VFD controls (motor speed)		TBD					
	T/C or RTD in transfer pump motor, indication with VFD display		TBD					
	on-line sampler (transfer flush water chemistry) TBD if required.							
	flow totalizer with remote indication (transfer flush water)		TBD					
AZ-102	hydrogen analyzer (continuous, on-line sampling)		CH1 0-10% H2 CH2 0-1% H2	Not required	Required	Low or FAIL Required	Not required	
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)		-25.4 to +12.7 cm (-10 to +5 in. WG)	Required	Required	Required	Required	
	stack isokinetic probe/control system (exhaust flow)		Stack Flow: 0 to 24.7 m/min (0 to 871 scfm) Sample Flow: 0 to 57 L/min (0 to 2 scfm)		Required	Required		
	pressure transmitter with remote switch and indication (tank diluent)		0-TBD		Required			
	pressure transmitter with remote switch and indication (raw water)		1.01 to 7.81 kPa (0 to 100 psig)					

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation	Range	Setpoints functions				Comment/issue
			HiHi	Hi	Lo	LoLo	
AZ-102 (cont.)	CAM with interlock to exhaust fan	TBD					
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	TBD		Required	Required	Required	
	conductivity probes set at proper elevations (annulus leak detectors)	0-10,000 cps leak 2.54 cm (1 in.) and 25.4 cm (10 in.) in leak detection pit		Required	Low or Fail Required		
	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	TBD	Required	Required	Required		To provide temperature gradient information to protect tank integrity
	raw water flow totalizer (primary tank)	0-TBD L	Not required.	Required	Required		
	ENRAF™ level system (primary tk.)	0 to 9.25 m (0 to 364 in.)	Required	Required	Required		
	trend recorder connected to waste temperature monitoring system	0-TBD		Delta T between set of TEs (TBD)			
	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators)	1.01 to 3.42 kPa (0 to 35 psig) and 566 L/min (20 scfm)		Temp Hi required	Press-Low Flow-Low		

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation	Range	Setpoints functions				Comment/issue
			HiHi	Hi	Lo	LoLo	
AZ-102 (cont.)	on-line analyzer (continuous) for diluent water chemistry	pH TBD-TBD, Conductivity TBD-TBD micromho, Viscosity TBD-TBD cP					
	flow totalizer with remote flow indicator (diluent)	0 to 454 m^3 (0 to 120,000 gal)		Required to indicate approaching set value.			
	ENRAF™ system; URSILLA system (primary tank density)			Required			
	grab sample with remote analysis (slurry viscosity) TBD if required.						
	mixer pump VFD (motor speed and rotation motor speed)			Required	Required - pump/motor protection		
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration) TBD if required.			Required-pump/motor protection			
	In-tank camera with controls and air or nitrogen purge pressure and flow	flow 0 to 85 L/min (0 to 3 scfm), Pressure 1.01 to 5.15 kPa (0 to 60 psig)		Required			
	turntable drive position indication	0-180 °		TBD	TBD		
	mass flow meter (slurry transfer)	0-TBD kg/hr					
	pressure transmitter with remote indication (transfer piping diluent)	0-TBD kPa		Required-to indicate approaching the set value.			

Table C-5. Monitoring And Control Instrumentation Parameters Needed For 241-AZ Tank Farm In Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation		Range	Setpoints functions				Comment/issue
				HiHi	Hi	Lo	LoLo	
AZ-102 (cont.)	flow totalizer (transfer diluent)				Required to indicate approaching set value			
	pressure transmitter at each end of transfer piping with remote indicator and comparator				Required-line protection & to indicate line plug			
	pressure transmitter with remote indication (transfer piping)				Required-line protection			
	grab sampler (slurry transfer)		N/A					
	pressure transmitter with remote indication (transfer pump discharge)		1.01 to 32.0 kPa (0 to 450 psig)					
	transfer pump VFD controls and indication (speed)		TBD					
	local accelerometers with remote indication (transfer pump/motor vibration) TBD if required.		TBD					
	transfer pump VFD controls (motor speed and current)		TBD					
	T/C or RTD in transfer pump motor, indication with VFD display		TBD					
	flow totalizer with remote indication (transfer line flush water)		TBD					
	on-line sampler (transfer flush water chemistry) TBD if required.		TBD					

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-101	hydrogen analyzer (continuous, on-line sampling)	Yes	AZ101-SHM-NASH-054 (0 to 10% H2) and AZ101-SHM-NASH-055 (0 to 1% H2)			W-369 (Dwg No.H-14-100835.
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)	Yes	PIT-AZ101K1-1			702-AZ (W-030) (Dwg#H-2-131075 sh2)
	stack isokinetic probe/control system (exhaust flow)	Yes	AE-AZK1-1 and AE-AZK1-2			702-AZ (W-030) (Dwg#H-2-131078 sh1)
	pressure transmitter with remote switch and indication (tank diluent)	TBD				
	pressure transmitter with remote switch and indication (raw water)	Yes	PT-AZRW-1			Dwg # H-2-131074 H-2-131348
	CAM with interlock to exhaust fan	Yes	RAH-AZK1-1			702-AZ (W-030), Interlocks I-108 & I-119 from TMACS (Dwg # H-2131078
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	Yes	PDAH & PDAHH-AZK14-1B (1A) & -2B (2A). PDAH& PDAHH-AZK110-1B (1A)			702-AZ (W-030) Interlock I-119 (Dwg # H-2-131076.
	conductivity probes set at proper elevations (annulus leak detectors)	Yes	WFT101-1,&101-2,and PAD101-1			H-2-68335 Sh 6

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-101 (cont.)	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	No		No		At present, there are Type J thermocouples (set of three thermocouples spaced at 4 in.,14 in.,and 140 in. from bottom) installed in risers 13B,13C,13D,and 13A. And another set of three thermocouples located at 4 in. from bottom in risers 16A, B, and C. This will not provide temperature gradient information required during transfer.
	raw water flow totalizer (primary tank	No		Yes	W-211	
	ENRAF™ level system (primary tk.)	Yes				Installed by W-151. For accuracy purpose during transfer , CIU will be required.
	trend recorder connected to waste temperature monitoring system	Yes				
	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators)	Flow-Local Pressure-No	AZ101-SA-FI-XX01(XX=01 thru22)	No		
	on-line analyzer (continuous) for diluent water chemistry	No		No		
	flow totalizer with remote flow indicator (diluent)	No		Yes	W-211	

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-101 (Cont.)	ENRAF™ system; URSILLA system (primary tank density)	No		Yes	W-151	CVI#22515,supp 40,41. ENRAF™ Densitiometer not planned or bought by W-151.
	grab sample with remote analysis (slurry viscosity)	No		No		
	mixer pump VFD (rotational speed)	No		Yes	W-151	CVI#22515,supp 32.
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration)	No		Yes	W-151	CVI#22515,supp 32
	In-tank camera with controls and air or nitrogen purge pressure and flow	No		Yes	W-151	CVI#22515,supp 44
	turntable drive position indication (part of mixer pump VFD system)	No		Yes	W-151	CVI#22515,supp32.
	mass flow meter (slurry transfer)	No		Yes (TBR)	W-211	Not in design yet, Discussion with project Inst. engineer indicates that this instrument will be part of design. Must be verified at design review.
	pressure transmitter with remote indication (transfer piping diluent)	No		TBR		Must be verified for inclusion in design at design review.
	flow totalizer (transfer diluent)	No		TBR		Must be verified for inclusion in design at design review.
	pressure transmitter at each end of transfer piping with remote indicator and comparator	No		No		
	pressure transmitter with remote indication (transfer piping)	No		No		

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-101 (cont.)	grab sampler (slurry transfer)	No		No		
	pressure transmitter with remote indication (transfer pump discharge)	No		No		The Decant/Transfer pump may not perform the function. The specific issue needs to TBR.
	transfer pump VFD controls and indication (speed)	No		No		See note above
	local accelerometers with remote indication (transfer pump/motor vibration)	No		No		
	transfer pump VFD controls	No		No		
	T/C or RTD in transfer pump motor, indication with VFD display	No		No		
	flow totalizer with remote indication (transfer line flush water).	No		TBR	W-211	To be verified at Design Review.
	on-line sampler (transfer flush water chemistry)	No		TBR	W-211	To be verified at Design Review.
AZ-102	hydrogen analyzer (continuous, on-line sampling)	Yes	AZ102-SHM-NASH-054 (0 to 10% H2) and AZ102-SHM-NASH-055 (0 to 1% H2)			W-369 (Dwg No.H-14-100835.
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)	Yes	PIT-AZ102K1-1			702-AZ (W-030) (Dwg#H-2-131075 sh2)
	stack isokinetic probe/control system (exhaust flow)					AZ-101 & AZ-102 share a common system.

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-102 (cont.)	pressure transmitter with remote switch and indication (tank diluent)	No		No		
	pressure transmitter with remote switch and indication (raw water)	TBD				
	CAM with interlock to exhaust fan	Yes				AZ-101 & AZ-102 share a common system.
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	Yes				AZ-101 & AZ-102 share a common system.
	conductivity probes set at proper elevations (annulus leak detectors)	Yes	WFT102-1,& 102-2& PAD102-1			H-2-68335 sht 2
	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	No		No		At present, there are Type J thermocouples (set of three thermocouples spaced at 4 in.,14 in.,and 140 in. from bottom) installed in risers 13B,13C,13D,and 13A. And another set of three thermocouples located at 4 in. from bottom in risers 16A, B, and C. This will not provide temperature gradient information required during transfer.
	raw water flow totalizer (primary tank)	TBD				
	ENRAF™ level system (primary tk.)	No		No		
	trend recorder connected to waste temperature monitoring system	Yes				

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-102	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators)	Pressure-No Flow-Local	AZ102-SA-FI-XX01(XX=01 thru 22)	No		
	on-line analyzer (continuous) for diluent water chemistry	No		No		
	flow totalizer with remote flow indicator (diluent)	No		No		
	ENRAF™ system; URSILLA system (primary tank density)	No		No		
	grab sample with remote analysis (slurry viscosity)	No		No		
	mixer pump VFD (rotational speed)	No		Yes	W-211	
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration)	No		Yes	W-211	
	In-tank camera with controls and air or nitrogen purge pressure and flow	No		Yes	W-211	
	turntable drive position indication (part of mixer pump VFD system)	No		Yes	W-211	
	mass flow meter (slurry transfer)	No		Yes	W-211	
	pressure transmitter with remote indication (transfer piping diluent)	No		Yes	W-211	
	flow totalizer (transfer diluent)	No		Yes	W-211	
	pressure transmitter at each end of transfer piping with remote indicator and comparator	No		No		

Table C-6. Monitoring and Control Equipment Available for 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control equipment needed	Equipment installed?		Equipment planned?		References/comments
		Yes/No	EIN or Label	Yes/No	Project No.	
AZ-102 (cont.)	pressure transmitter with remote indication (transfer piping)	No		No		
	grab sampler (slurry transfer)	No		No		
	pressure transmitter with remote indication (transfer pump discharge)	No		Yes	W-211	
	transfer pump VFD controls and indication (speed)	No		Yes	W-211	
	local accelerometers with remote indication (transfer pump/motor vibration)	No		Yes	W-211	
	transfer pump VFD controls (direction of rotation and motor current)	No		Yes	W-211	
	T/C or RTD in transfer pump motor, indication with VFD display	No		Yes	W-211	
	flow totalizer with remote indication (transfer line flush water)	No		No		
	on-line sampler (transfer flush water chemistry)	No		Yes	W-211	

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-101	hydrogen analyzer (continuous, on-line sampling)	Yes	Existing system has two channels which cover narrow range and wide range.	
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)	TBD		existing PIT is calibrated for -15.2 to +10.2 cm (-6 to +4 in. WG.) Needs re-calibration of the loop to span from -25.4 to +12.7 cm (-10 to +5 in WG).
	stack isokinetic probe/control system (exhaust flow)	TBD	Existing system is designed for flow variations of 11.3 to 28.3 m^3/min (400 to 1000 scfm).	If mixer pump/transfer pump operation does not increase exhaust flow of 28.3 m^3/min (1000 scfm), existing system would be adequate. If flow increases beyond 28.3 m^3/min (1000 scfm), some changes to the systems- such as verification of isokinetic nozzles, re-calibration of flow monitoring loop would be required.
	pressure transmitter with remote switch and indication (tank diluent)	TBD		
	pressure transmitter with remote switch and indication (raw water)	Yes	existing instrument has adequate range.	
	CAM with interlock to exhaust fan	TBD	existing system design adequate if radiolytic emission contains beta & gamma only .	
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	Yes	Existing system design has adequate instrumentation to indicate HEPA filter condition.	

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-101 (cont.)	conductivity probes set at proper elevations (annulus leak detectors)	Yes	Existing system has adequate instrumentation to detect presence of liquid.	
	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	No		existing temperature system is not adequate during mixer pump operation as uniform temperature gradient over the entire length of liquid column will be used to determine completion of mixing operation
	raw water flow totalizer (primary tank)	TBD		
	ENRAF™ level system (primary tk.)	Yes	W-151 is installing ENRAF™ which would give better accuracy of level measurement once CIU is installed to transmit digital signal.	CIU required to be installed to get accurate level measurement for quantity transfer calculations.
	trend recorder connected to waste temperature monitoring system	TBD		existing trend recorder system will need re-calibration for temperature gradient data record as well as rate of change annunciation
	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators) and air lift circulator temperature indication.	TBD	Existing system design provides this information.	Need to verify air flow and pressure adequacy to maintain waste temperature below 93 °C (200 °F) sludge temperature below 110 °C (230 °F) by air lift circulator operation. Need to verify operating time and air supply capacity.
	on-line analyzer (continuous) for diluent water chemistry	TBD		
	flow totalizer with remote flow indicator (diluent)	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-101 (cont.)	ENRAF™ system; URSILLA system (primary tank density)	TBD		
	grab sample with remote analysis (slurry viscosity)	TBD		
	mixer pump VFD (rotational speed)	TBD		
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration)	TBD		
	In-tank camera with controls and air or nitrogen purge pressure and flow	TBD		
	turntable drive position indication (part of mixer pump VFD system)	TBD		
	mass flow meter (slurry transfer)	TBD		
	pressure transmitter with remote indication (transfer piping diluent)	TBD		
	flow totalizer (transfer diluent)	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-101 (cont.)	pressure transmitter at each end of transfer piping with remote indicator and comparator	TBD		
	pressure transmitter with remote indication (transfer piping)	TBD		
	grab sampler (slurry transfer)	TBD		
	pressure transmitter with remote indication (transfer pump discharge)	TBD		
	transfer pump VFD controls and indication (speed)	TBD		
	local accelerometers with remote indication (transfer pump/motor vibration)	TBD		
	transfer pump VFD controls (direction of rotation and motor current)	TBD		
	T/C or RTD in transfer pump motor, indication with VFD display	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-101 (cont.)	flow totalizer with remote indication (transfer line flush water)	TBD		
	on-line sampler (transfer flush water chemistry)	TBD		
	flow totalizer with remote indication (transfer flush water)	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-102	hydrogen analyzer (continuous, on-line sampling)	Yes	Existing system has two channels which cover narrow range and wide range.	
	pressure transmitter (dp or absolute) with remote indication/alarm (vapor space)	TBD		existing PIT is calibrated for -15.2 to +10.2 cm (-6 to +4 in. WG). Needs re-calibration of the loop to span from -25.4 to +12.7 cm (-10 to +5 in. WG).
	stack isokinetic probe/control system (exhaust flow)	TBD	Existing system is designed for flow variations of 400-1000 scfm.	If mixer pump/transfer pump operation doesn't increase exhaust flow of 28.3 m^3/min (1000 scfm), existing system would be adequate. If flow increases beyond 28.3 m^3/min (1000 scfm), some changes to the systems- such as verification of isokinetic nozzles, re-calibration of flow monitoring loop would be required.
	pressure transmitter with remote switch and indication (tank diluent)	TBD		
	pressure transmitter with remote switch and indication (raw water)	Yes	existing instrument has adequate range.	
	CAM with interlock to exhaust fan	TBD	existing system design adequate if radiolytic emission contains beta & gamma only.	
	differential pressure transmitter with local/remote indication and interlock with exhaust fan (HEPA)	TBD	Existing system design has adequate instrumentation to indicate HEPA filter condition.	

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-102 (cont.)	conductivity probes set at proper elevations (annulus leak detectors)	Yes	Existing system design has adequate instrumentation to detect presence of liquid.	
	RTDs at elevations to give temperature gradients at various tank levels (primary tank)	No		existing temperature system is not adequate during mixer pump operation as uniform temperature gradient over the entire length of liquid column will be used to determine completion of mixing operation
	raw water flow totalizer (primary tank)	TBD		
	ENRAF™ level system (primary tk.)	Yes	W-151 is installing ENRAF™ would give better accuracy of level measurement once CIU is installed to transmit digital signal.	CIU required to be installed to get accurate level measurement for quantity transfer calculations.
	trend recorder connected to waste temperature monitoring system	TBD		existing trend recorder system will need re-calibration for temperature gradient data record as well as rate of change annunciation
	pressure and flow transmitters with local and remote indication (instrument air system for air lift circulators)	TBD	Existing system design provides this information.	Need to verify air flow and pressure adequacy to maintain waste temperature below 93 °C (200 °F) sludge temperature below 110 °C (230 °F) by air lift circulator operation. Need to verify operating time and air supply capacity.
	on-line analyzer (continuous) for diluent water chemistry	TBD		
	flow totalizer with remote flow indicator (diluent)	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-102 (cont.)	ENRAF™ system; URSILLA system (primary tank density)	TBD		
	grab sample with remote analysis (slurry viscosity)	TBD		
	mixer pump VFD (rotational speed)	TBD		
	accelerometer with remote indication at VFD control station (mixer pump/motor vibration)	TBD		
	In-tank camera with controls and air or nitrogen purge pressure and flow	TBD		
	turntable drive position indication (part of mixer pump VFD system)	TBD		
	mass flow meter (slurry transfer)	TBD		
	pressure transmitter with remote indication (transfer piping diluent)	TBD		
	flow totalizer (transfer diluent)	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-102 (cont.)	pressure transmitter at each end of transfer piping with remote indicator and comparator	TBD		
	pressure transmitter with remote indication (transfer piping)	TBD		
	grab sampler (slurry transfer)	TBD		
	pressure transmitter with remote indication (transfer pump discharge)	TBD		
	transfer pump VFD controls and indication (speed)	TBD		
	local accelerometers with remote indication (transfer pump/motor vibration)	TBD		
	transfer pump VFD controls (direction of rotation and motor current)	TBD		
	T/C or RTD in transfer pump motor, indication with VFD display	TBD		

Table C-7. Comparison of Process Monitoring and Control Needs to Available Monitoring and Control Equipment in 241-AZ Tank Farm in Support of Phase 1 Feed Delivery.

Tank	Monitoring and control instrumentation/equipment	Is existing and planned instrumentation adequate? (Y/N)	Basis for adequacy assessment	Comments/issues
AZ-102 (cont.)	flow totalizer with remote indication (transfer line flush water)	TBD		
	on-line sampler (transfer flush water chemistry)	TBD		

APPENDIX D

VENTILATION SYSTEM PROCESS NEEDS AND ASSESSMENT

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APPENDIX D

VENTILATION SYSTEM PROCESS NEEDS AND ASSESSMENT

Table 4-1 has identified quantitative process needs that must be met in order to enable tank waste remediation system (TWRS) to adequately deliver appropriate waste feed during Phase 1 privatization. A number of these quantitative process needs are specific to and rely on specific performance of the ventilation system. The ventilation system must be present to support feed delivery to the Phase 1 privatization contractor as well as ongoing TWRS operations during the Phase 1 privatization time frame. For the purposes of this evaluation of 241-AZ tank farm, the ventilation system consists of both the primary ventilation system and the annulus ventilation system. The quantitative process needs identified in Table 4-1 that apply to the ventilation system are presented in the sections below. Quantitative safety-related expectations are presented in Table 4-2.

D.1 VENTILATION SYSTEM EXPECTATIONS

The primary ventilation system must remove heat, air, evaporated water and evolved gases and particulate from the primary tank. The annulus ventilation system must remove heat and moisture and sweep the annular space to radiation detectors. The quantitative process needs that apply to the ventilation system are summarized as part of Table D-1. The safety-related requirements for the ventilation system are summarized in Table D-2.

D.2 EXISTING AND PLANNED VENTILATION SYSTEM

D.2.1 Previous Aging Waste Facility Primary Ventilation System (241-A-702)

The original design of the 241-A-702 primary ventilation system was an active ventilation system that provided primary tank ventilation for the four aging waste facility (AWF) tanks (241-AY-101, 241-AY-102, 241-AZ-101 and 241-AZ-102) and for the 241-AX-152 diverter station. Several other miscellaneous structures (e.g., the 241-AZ-151 and 241-AZ-154 catch tanks) were ventilated indirectly through waste transfer lines. The primary ventilation system was designed specifically for plutonium-uranium extraction (PUREX) generated aging waste (or boiling waste), which is exceptionally "hot" both thermally and radiologically.

Table D-1. Comparison of Process Needs to Existing and Planned Equipment for Ventilation in 241-AZ Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
5.P2.2. HLW: The variability of suspended solids concentrations should vary <20% (TBR) over the full depth prior to sampling and prior to beginning each feed transfer.	Primary Ventilation - Air Inlet & Infiltration, Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Primary High Efficiency Mist Eliminator, Primary Heaters, HEPA Filter and HEGA Train, Exhaust Fan, Stack During mixer pump operation, provide ventilation air flow to: 1. maintain tank head space at negative pressure; and 2. remove heat generated during mixer pump operation to homogenize tank contents.	Maintain Tank Head Space at Negative Pressure - TBD Remove Heat Generated During Mixer Pump Operation to Homogenize Tank Contents - TBD	See comments.	Maintain Tank Head Space at Negative Pressure - 1. The primary ventilation system fans AZ-K1-5-1A and AZ-K1-5-1B performance need to be upgraded to meet the design condition of 28 m^3/min (1000 cfm) at 956 Pa (32 in. WG) with operation in a stable portion of the fan pressure curve (negative sloped portion of the pressure curve). 2. Seal off each tank so that inlet air to the primary tank headspace flows through the 702-AZ (W-030) installed air inlet stations giving the capability to control system flow rates and achieve greater negative pressure in the primary tank. Remove Heat Generated During Mixer Pump Operation to Homogenize Tank Contents - TBD

Table D-2. Comparison of Safety-Related Needs to Existing And Planned Equipment For Ventilation in 241-AN Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
1.S1.3. Maintain flammable gases concentrations no greater than 25% of the lower flammability limit	Primary Ventilation - Exhaust Fan	TBD	Calculation F.5.2	Primary ventilation flow rates to maintain flammable gas concentrations below 25% of the lower flammability limit have not been completed. For comparison, the primary tank flow rate to maintain waste temperature to 73.9°C (165 °F) is more than ten times the flow rate required to maintain hydrogen concentration below 25% of LFL except for the Watch List Tanks.
1.S2.3. An active primary ventilation system shall be operable for all DSTs and AWTs	Primary Ventilation - Ducting, Primary Condenser, Primary High Efficiency Mist Eliminator, Primary Heaters, HEPA Filter and HEGA Train, Exhaust Fan, Stack	Yes.	The existing system is operable.	
1.S7.1. Primary tank ventilation stack CAM interlock systems shall be operable when active ventilation is operating.	Primary Ventilation - Stack	TBD	TBD	
1.S8.1. An active primary tank ventilation system for DSTs and AWF tanks shall be operable.	Primary Ventilation - Air Inlet & Infiltration, Ducting, Exhaust Fan, Stack Annulus Ventilation - Air Inlet, Ducting, Exhaust Fan, Stack	TBD	TBD	

Table D-2. Comparison of Safety-Related Needs to Existing And Planned Equipment For Ventilation in 241-AN Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
1.S9.1. Either the annulus conductivity probe system or the annulus continuous air monitor system shall be operable for DSTs and AWF tanks.	The annulus ventilation system for 241-AZ is not currently operating.	Yes	Conductivity probe system is operable	
1.S10.1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top4.6 m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6 m (15 ft).	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C [181 °F] calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.

Table D-2. Comparison of Safety-Related Needs to Existing And Planned Equipment For Ventilation in 241-AN Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
1.S10.2. Waste temperature shall not exceed 121°C (250 °F).	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C (181 °F) calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.
2.S1.1. Maintain tank headspace flammable gases concentrations no greater than 25% of the lower flammability limit.	Primary Ventilation - Exhaust Fan	TBD	Calculation F.5.2	Primary ventilation flow rates to maintain flammable gas concentrations below 25% of the lower flammability limit have not been completed. For comparison, the primary tank flow rate to maintain waste temperature to 73.9°C (165 °F) is more than ten times the flow rate required to maintain hydrogen concentration below 25% of LFL except for the Watch List Tanks.

Table D-2. Comparison of Safety-Related Needs to Existing And Planned Equipment For Ventilation in 241-AN Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
5.S1.1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top 4.6 m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6 m (15 ft).	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C (181°F) calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.
5.S1.2. Temperature changeover time for solutions in tanks shall be ≤5.5°C (10 °F)/hr (<52°C [125 °F]) or ≤11°C (20 °F) /day (≥52°C [125 °F])	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C (181°F) calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.

Table D-2. Comparison of Safety-Related Needs to Existing And Planned Equipment For Ventilation in 241-AN Tank Farm.

Quantitative tank-specific process need	Existing or planned structure, system, or component	Is existing and planned equipment adequate (Yes/No)	Basis	Comments/issues
5.S1.3. Temperature gradients of solution in tanks shall be ≤100°C (55 °F)/ft within the solution and at the solution/vapor interface	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C (181 °F) calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.
10.S1.1. Tank waste temperature shall be either: ≤90.6°C (195°F) in all levels of the waste; or ≤90.6°C (195°F) in the top 4.6 m (15 ft) of the waste and ≤102°C (215°F) in the waste below 4.6 m (15 ft).	Primary Ventilation - Recirculation Ventilation Cooling System, Recirculation Condenser Cooling System, Ducting, Primary Condenser, Exhaust Fan Provide ventilation air flow to remove heat generated during waste feed delivery operations.	Yes, based on preliminary results	See Calculation F.5.1	Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C (181 °F) calculated in the preliminary calculations). More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.

Air was introduced into an AWF tank headspace through air lift circulators and air purge instruments. Also, outside air was drawn into the tank through pit cover blocks and risers due to the vacuum created by the exhaust blower. Two 113-m^3/min (4,000-cfm) exhausters (blowers) operated one at a time to draw the gases through a particle and condensate removal system before discharging the gases to the atmosphere. Vapor was exhausted to the K1-5-1 deentrainer. After passing through the deentrainer, the vapor was routed to the 241-A-401 Surface Condenser Building. Three condensers (two in operation at a time) for removing moisture from the exhaust system were located in this building. The offgases from the three surface condensers were vented through a second deentrainer (K1-5-2A) before entering the 241-A-702 Ventilation Building. The vapor stream then continued into the K1-3-1 steam heater housing before reaching the filter banks. Twelve high-efficiency particulate air (HEPA) filters, in six banks, simultaneously filtered the exhaust air flowing through the 241-A-702 Primary Ventilation System. After filtration the vapor was discharged by the blower into the atmosphere via the stainless steel exhaust stack. A continuous air monitor (CAM) monitored effluent radioactivity levels, and a record sampler collected representative samples before the vapor stream was discharged to the atmosphere.

D.2.2 Modification to Aging Waste Facility Primary Ventilation System through Project W-030 (241-AZ-702)

The original AWF primary ventilation system was modified by Project 702-AZ (W-030) by incorporating several changes. The primary tank ventilation system contains individual controlled air inlets and a common ventilation off-gas exhaust for the four AY and AZ Tank Farm waste tanks (241-AY-101, 241-AY-102, 241-AZ-101, and 241-AZ-102). The individual tank air inlet consists of a heater, pre-filter, HEPA filter, flow control valve, manifolded into a common exhaust stream and then cooled and filtered prior to being exhausted to the atmosphere through a stack. The filter/fan train is redundant to maintain tank pressures during anticipated maintenance or accidental component failure.

Process ventilation is required to maintain a negative pressure in the waste storage tanks of approximately 1010 to 1005 Pa (-1 to -3 in. WG) to provide cooling and to dilute any potentially flammable gases. Instrumentation is provided at each tank to monitor and control pressure. A negative pressure in the tank is controlled by operating a control valve on the air inlet systems.

Each tank is provided with a heated, HEPA filtered air inlet system. The air inlet system is provided with a vacuum relief valve to protect the tanks from unexpected high negative pressure.

A recirculation ventilation cooling system is provided for each waste tank to help reduce emissions and remove heat generated in the tanks. The cooling equipment is located in concrete vaults and includes a condenser, moisture separator and recirculation fan for each system. The vaults are reinforced concrete structures with equipment access from the top and personnel access through a door.

The recirculation ventilation cooling system draws approximately 14.2 m^3/min (500 scfm) of process gas from the waste tank with the recirculation fan, and returns from 0 to 11.3 m^3/min (0 to 400 scfm), depending on the tank heat load. The remaining tank vapor from 2.83 to 14.2 m^3/min (100 to 500 scfm) is exhausted through the primary tank ventilation system. The inlet to the recirculation fan is provided with a moisture separator to protect it from erosion. The 14.2 m^3/min (500-scfm) flow through the shell side of the condenser is sufficient to remove approximately 257 kW (878,000 Btu/hr) at a tank off-gas temperature of 88.9°C (192°F). (For condenser AZ101-K4-8-1 it is approximately 440 kW [1.5 M Btu/hr] at a tank off-gas temperature of 96.1°C [206°F].) The heat is rejected with a closed-loop evaporative cooling tower to the atmosphere.

The recirculation condenser cooling system consists of an evaporative fluid cooler, two circulation pumps, an expansion tank, an air separator, and instruments for monitoring the closed loop cooling system. The cooling medium used is 40 percent by volume propylene glycol mixture that is circulated between the evaporative fluid cooler and the recirculation condenser.

When the tank off-gas temperature is sufficiently low the condenser cooling ceases to occur, the recirculation ventilation cooling system is bypassed.

When the waste tank mixer pumps are placed in operation, valves for that tank are aligned for high-heat mode and the inlet airflow out of the tank is increased from 100 scfm to a maximum of 14.2 m^3/min (500 scfm).

The combined exhaust stream from all four tanks flows through condenser AZ-K1-81 where it is cooled to 4.4°C (40 °F) and then through the HEME to eliminate any water droplet carry over into the filter system. The condensate from the condenser and HEME drains to a seal pot and that drains into a condensate tank.

Upon exiting the HEME, the gas stream is heated by electric heaters to protect the HEPA and HEGA filters downstream from the effects of high humidity conditions (wetting and possible blow out of the filters).

Each heater system and an associated filter bank are contained in a train. The operating heater is determined by which filter bank is operating. Normally, one train will be in operation while the second train is in standby. Each bank consists of two HEPA filters and a Charcoal Adsorber (HEGA). Instrumentation is provided for each bank to monitor pressure differential across each stage and temperature downstream of each bank. The system shuts down and switches over to the standby train upon high differential pressure across any stage of the filter train, upon heater failure, or when the heater high temperature set point is tripped.

The ventilation gas stream, after passing through one of the two filter banks, is exhausted by one of two exhaust fans up the exhaust stack to the atmosphere. One fan is in standby while the operating fan maintains a vacuum on the four storage tank vapor spaces.

Instrumentation is provided for each fan to monitor speed, inlet damper, outlet damper and backdraft damper position status. Controls are provided to operate the fan while providing status via current monitoring.

The exhaust stack is external to the ventilation building and extends 16.8 m (55 ft) above the ground. The stack provides the point of discharge for the primary tank ventilation system. The primary exhaust air stream is sample for the particulate and iodine, and is monitored for beta/gamma radioactivity at the exit duct prior to discharge via the stack. The exhausted air stream is also monitored for flow.

For a more detailed description of how the 702-AZ (W-030) ventilation upgrades are designed to perform refer to HNF-1903, "Project 702-AZ (W-030) Tank Farm Ventilation Upgrade System Descriptions".

D.2.3 Existing Aging Waste Facility Annulus Ventilation System

The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational and leak detection for the primary tank is provided by conductivity probes in the tank annulus. Next year plant maintenance plans to restore the system to operation under its original configuration (one for one replacement of failed components). It is not known at this time if the Project W-151 mixer pump tests will require a functional annulus exhaust system or if the system will be functional to support the testing.

D.3 COMPARISON OF EXISTING AND PLANNED EQUIPMENT TO EXPECTATIONS

D.3.1 Primary Ventilation Exhaust Fan

Suspension of solids within the Aging Waste Facility tanks is provided by operation of mixer pumps. The mixer pumps generate heat which in turn increases water and particulate generation. The ventilation system must be adequately sized to accommodate the tank mixing operations during Phase 1 privatization feed delivery by removing heat, particulate, and water while maintaining vacuum within the tank headspace. Table D-1 identifies that the existing primary ventilation exhaust fan is not adequate to provide the necessary level of vacuum and too much air in leakage is occurring into the Aging Waste Facility tanks to allow control of the ventilation flows through each tank.

The primary ventilation fans in the 702 AZ Building, AZ-K1-5-1A and AZ-K1-5-1B, performance has been reviewed against Project 702-AZ (W-030) design requirements. The "Results and Conclusions" for Calculation 702-AZ (W-030)-23, "Primary Ventilation Exhaust Fan Capacity" specified 1093 Pa (32 in. WG) @ 28.3 m^3/min (1000 cfm) maximum and 1050 Pa (15 in. WG) @ 11.3 m^3/min (400 cfm) minimum. Procurement Specification W-030-P3 "Primary Ventilation Air Clean-up Trains," paragraph 3.1.5, specifies fan design conditions are:

Normal Operation -

Min flow: 11.3 m^3/min (400 cfm) 400 scfm @ 1050 Pa (15 in. WG)
Max flow: 28.3 m^3/min (1000 cfm) @ 1093 Pa (32 in. WG)

Vendor Information for Project 702-AZ (W-030), 0022525 supplement 113, Ellis & Watts, Air Clean-up Train has a subset of data supplied by American Fan with the following pertinent data:

1. Quality Assurance Final Inspection Centrifugal Fan: motor 20hp Westinghouse 1755 RPM and running RPM= 3600 for one fan and 3590 RPM for the other with a vibration analysis at both speeds.

2. Certificate of Analysis and Tests, 18.0 American Fan for R13-303-3575-195 (pressure curves)
   TB-8996 @ 2685 RPM (1050 Pa [15 in. WG] @ 19.8 m^3/min [700 cfm])
   TB-8998 @ 3895 RPM (1093 Pa [32 in. WG] @ 28.3 m^3/min [1000 cfm])

It appears the variable speed control on the 1800 RPM 15 kW (20 HP) motor limits the fan speed to 3600 RPM and it is estimated that the fan would operate at approximately 1080 Pa (27 in. WG) @ 26.2 m^3/min (925 cfm) which is below the design point of 1093 Pa (32 in. WG) @ 28.3 m^3/min (1000 cfm).

The following is referenced from "Fan Engineering," published by Buffalo Forge Co.: The fan should be selected on the negatively sloping portion of the pressure curve and adequate margin should be provided so that a disturbance will not force the fan to operate at the peak. If the fan is forced to operate on the positively sloping portion of the pressure curve, instability may result accompanied by changes in pressure power and noise. In discussion with Mark Fritzjerld from the American Fan Co., he confirmed that this model fan should only be operated on the negative sloped portion of the pressure curve. Review of the performance data indicates that the primary ventilation system fan operates on the positive sloped portion of the pressure curve and the system design performance requirement is at the peak of the curve (3895 RPM) and is not attainable since the fan maximum speed is 3600 RPM.

For the AWF to meet the design and performance requirements for Project 702-AZ (W-030) the fan and drive apparatus will require design modifications. These modifications are currently being reviewed by the PHMC. The primary ventilation system fans AZ-K1-5-1A and AZ-K1-5-1B performance need to be upgraded to meet the Procurement Specification W-030-P3 fan design condition of 28.3 m^3/min (1000 cfm) at 1093 Pa (32 in. WG) with operation in a stable portion of the fan pressure curve (negative sloped portion of the pressure curve).

D.3.2 Primary Ventilation System Filter Train

During operation of the 702-AZ (W-030) upgraded system there have been two instances where the filter plenum housings have had moisture collection problems. When the system initially started up the sealpot drain line tie in at 241-151-AX catch tank was blocked and liquid flooded the sealpot and backed up into the filter plenum housings. The next time moisture collected in the filter plenum housings the condenser and HEME in the 702-AZ building were operated in a by-pass mode and after 4 days approximately 132 l (35 gal) had accumulated in the housing. The operations engineers stated there was no time for planned outages of the condenser and HEME because of the flooding problem and a redundant system (condenser and HEME or just HEME) would be desired. Additionally, the primary ventilation system HEPA and HEGA filter plenums are not in compliance with ANSI N509, Section 5.6.2. "The drain system shall be designed so that no unacceptable backup of liquids into the housing will occur" and "Each housing compartment shall have floor drains which meet all allowable air leakage criteria." Both filter housings should have drain capability added for all compartments.

D.3.3 Equipment Installation and Removal from Aging Waste Facility Tanks

Equipment (thermocouple tree, transfer pumps and mixing pumps) will require installation or removal from the DST which will create openings in the DST dome to atmosphere during this operation. To insure the containment of the DST vapors, a negative pressure in the tank dome needs to be maintained. The largest riser in the DST dome is 1.07 m (42 in.) in diameter which has an area of 0.89 m^2 (9.6 ft^2) open to the atmosphere. The existing ventilation system may not have enough capacity to insure that the tank dome can be maintained at a negative pressure and perform all its other functions for the other three tanks in the system.

The recirculation module for each AWF tank has two 20-cm (8-in.) connections and required valving options to install a portable exhauster to increase the ventilation flow in conjunction with the existing ventilation system capacity and a negative pressure is expected to be maintained in the primary tank dome. Verification needs to be performed or existing documentation substantiated to assure how the ventilation system will be configured to maintain a negative pressure in the tank dome during equipment change out.

D.3.4 Slurry Distribution

An evaluation was performed by J.R. Kriskovich, on the slurry distribution in 241-AY-101 and its affects on the AWF ventilation system, *Slurry Distributor Affects on Ventilation System* (Kriskovich 1998). The conclusions were:

- Primary tank dome vapor space can be maintained at a negative pressure during slurry distributor operation.
- Aerosol/moisture removal was achieved.
- Higher radiation in the re-circulation module was occurring due to aerosol/moisture settling out in piping, ductwork and equipment.

The report concluded in order to reduce the radiation buildup in the re-circulation modules a dropleg or some other method of transferring directly into the tank contents is recommended over the current practice of using a slurry distributor. Use of slurry distributor as delivery point of waste being transferred into an AWF DST tank should be abandoned and an evaluation of alternate delivery methods for transferring waste into the tank should be pursued (minimization of aerosol distribution into the tank vapor space) (Kriskovich 1998 Draft).

D.3.5 Annulus Ventilation System

The annulus system for the 241-AZ tanks is a combined system for both tanks. At this time the annulus system is not operational and leak detection for the primary tank is provided by conductivity probes in the tank annulus. Next year plant maintenance plans to restore the system to operation under its original configuration (one for one replacement of failed components). It is not known at this time if the Project W-151 mixer pump tests will require a functional annulus exhaust system or if the system will be functional to support the testing.

D.3.6 Air In Leakage and Vacuum Control

The primary tank air inlet stations are not now in operation and are valved shut. The inlet air is from air lift circulation (if operating) and outside air drawn into the tank through pit cover blocks, risers or uncapped transfer lines that are open to other sources such as the 241-AX-152 diverter station. If the in leakage air can be controlled to a minimal amount then the 702-AZ (W-030) primary tank air inlet stations can be utilized in the overall ventilation control. Sealing off each tank so that inlet air to the primary tank headspace flows through the 702-AZ (W-030) installed air inlet stations woulld give the capability to control system flow rates and achieve greater negative pressure in the primary tank.

D.3.7 Thermal Analysis of Tank 241-AZ-101 Waste Removal

A preliminary thermal analysis (Appendix E-1) of tank temperature rise with mixer pump operation in tank AZ-101 predicts a final temperature of 82.8°C (181°F) after 138 hours of operation associated with the first transfer to the private contractor. The waste temperature prior to mixer pump operation was 65.6°C (150°F) with 88 kW (300,000 BTU/Hr) radionuclide heat generation from the waste, annulus flow rate of 22.7 m^3/min (800 scfm) and primary ventilation flow rate of 14.2 m^3/min (500 scfm). This preliminary calculation does not account for temperature profiles within the non-convective layer of solids at the bottom of the tank. Upon settling, this solids layer is expected to rise in temperature above the bulk temperature of the solution (i.e., higher than the 82.8°C [181°F] calculated in the preliminary calculations).

More detailed analysis will be required to verify the preliminary calculations, but the initial results indicate that the 702-AZ (W-030) revised AWF ventilation system will adequately remove heat/condensate for mixer pump operation in one tank and provide adequate ventilation for the other three AWF tanks.

D.4 REFERENCES

Kriskovich, J. R., 1998, *Slurry Distributor Affects on Ventilation System*, HNF-2783, Rev. 0 Draft, Lockheed Martin Hanford Corporation, Richland, Washington.

Appendix D, Attachment 1: Assessment of In-Tank Concentration of NCAW Supernate

In tank concentration of the Neutralized Current Acid Waste (NCAW) in tanks 241-AZ-101 and 241-AZ-102 to approximately 5.0 M Sodium may be desired. The duration of concentration of the waste must be compatible with the Waste Feed Delivery Schedule for the Vitrification Plant. Concentration of this waste would serve two purposes: to provide additional usable DST storage space and to provide the private contractor a better waste feed. Concentration would be performed through removal of evaporated supernate (water vapor) using the tank ventilation system. The ventilation system uses condensers to remove moisture from its exhaust stream. This condensed liquid would then be collected in a Catch Tank.

On March 20, 1998, a new ventilation system (702-AZ) for the AWF was placed into service. The old system (702-A) ventilated all four tanks in the AWF in a once through fashion, in other words, the system had no recirculated air. The flow rate was approximately 14.2 m^3/min (500 SCFM) per tank through the exhaust stack. The new ventilation system also ventilates all four AWF tanks. This system recirculates 80 percent (11.3 m^3/min [400 CFM]) of the airflow through the tank and exhausts 20 percent (2.83 m^3/min [100 CFM]) per tank through the stack. The new system is not as efficient at removing evaporated condensate from the tank due to the reduced air removal rate from the tank and because the condensate in the recirculation system is returned to the tank it was removed from. The 20 percent that is exhausted is routed through the system condenser and the condensate is transferred to the AZ-151 Catch Tank where it is stored.

Condensate removed by the 702-AZ system is currently collected at Catch Tank AZ-151. At present, there is one RCRA compliant route from Catch Tank AZ-151 and it routes the condensate back into the 241-AZ tank farm. If concentration of the waste in both AZ-101 and AZ-102 is desired, a new, RCRA compliant route from Tank AZ-151 to another tank farm may be required.

Condensate could be transferred to Tank AY-101 via the following route: Catch Tank AZ-151 to AZ-152 and AZ-152 to AX-155, although there are a number of concerns. This transfer would be routed through two lines that are presently considered RCRA non-compliant. Line V-719 is a pipe-in-pipe line from AZ-152 to AX-155. The transfer from AX-155 to AY-101 could be performed through either of two lines, 4603 or 4506, neither of which are RCRA-compliant. Presently, plans were to make Tank AX-152 inactive. In order for this transfer to occur two new jumpers will have to be designed, constructed, tested and installed. The first jumper would be installed between Nozzles L1 and U4 at Catch Tank AZ-152. The second jumper would be installed between Nozzles U-13 and U-3 in AX-155. Additionally, Tank AX-152 would have to remain active as a Catch Tank for AX-155 in order to allow these transfers. The Project Hanford Management Company position on these lines is that they may be used as long as non-RCRA material being transferred through them. It is also PHMCs position that condensate is a non-RCRA waste (RCRA Integration Team, 1996).

A new line could be designed, constructed, tested and installed between Catch Tank

AZ-151 and tank 241-AY-101 to allow condensate removal from tanks 241-AZ-101 and 241-AZ-102. However, this option would likely be non-cost effective.

Liquid levels in tanks 241-AZ-101 and 241-AZ-102 are monitored on a daily basis. Liquid level decline in the 241-AZ tank farm can be attributed entirely to evaporation (Tardiff 1998). A distinct change in the liquid level trend for tank 241-AZ-101 occurred from 1/1/98 to 5/31/98 due to tow distinct operational phases. The first being the 702-A system operational phase. The decline in liquid level for this time frame is nearly constant. The second phase is from the initial startup of 702-AZ to the present. Once again the decline in liquid level has a nearly constant slope, however, the slope is less steep. Therefore, the system has a lower efficiency at vapor removal than the 702-A system. The decline in liquid level is quite constant in this case with the exception of a condensate transfer to the tank on 2/25/98. The second phase is during the 702-AZ operational phase, 3/20/98 to present. This region can be broken down into five subregions. The first region is a fairly constant decline in liquid level in the tank. The data indicates the liquid level declines at a slower rate using the 702-AZ system than the 702-A system. The next four subregions are similar in nature and are summarized as follows: a condensate waste transfer from Catch Tank AZ-151 to tank 241-AZ-102 followed by a slow decline in liquid level in the tank due to evaporation ending with the next condensate transfer into the tank. Refer to Appendix F.5.3 for depictions of these phenomena. These graphs allow determination of an evaporation rate per unit time. This is an important parameter which will allow determination of the feasibility of concentration of waste by evaporation.

At present, tank 241-AZ-101 contains 4.78 M Sodium concentration. The tank currently contains 3077 m^3 (813,000 gal) of supernate and 132 m^3 (35,000 gal) of sludge (Refer to calculations in Appendix F). The heat load is estimated to be 76.2-89.7 kW (260,000-306,000 Btu/hr) (Interoffice Memorandum 74650-97-013). It is desirable to deliver the waste at 5.0 M sodium. Calculations performed based on data collected (Refer to Appendix F) show at the average current rate of evaporation using the 702-AZ system it will take approximately 31.2 months to concentrate the supernate to 5.0 M, assuming that Catch Tank AZ-151 nor any other waste will be transferred into 241-AZ-101.Presently, tank 241-AZ-102 contains 2.36 M Sodium concentration (Refer to calculations in Appendix F.5.3). The tank currently contains 2964 m^3 (783,000 gal) of supernate and 359.6 m^3 (95,000 gal) of sludge. The current heat load is estimated to be 49 kW (168,000 Btu/hr) (Interoffice Memorandum 74650-97-013). It is desirable to deliver the waste at 5.0 M sodium. Calculations performed based on data collected (Refer to Appendix ??) show at the current average rate of evaporation using the 702-AZ system it will take approximately 1500 months to concentrate the supernate to 5.0 M assuming that Catch Tank AZ-151 nor any other waste will be transferred into AZ-102.

The present evaporation rate in tank 241-AZ-101 may be acceptable. However, at present the liquid level in the tank must remain above 7.82 m (308 in.) to allow mixer pump testing. This testing is scheduled to complete sometime in Fiscal Year (FY) 2000. At the time of completion concentration activities may begin. A possible solution to allow higher evaporation rates in 241-AZ-101 is to run the mixer pumps intermittently after testing has been successfully completed. The mixer pumps produce a great deal of heat (403 kW [1,375,000 Btu/hr]). Assuming one hundred percent of the heat generated went to evaporation and the mixer pumps were allowed to operate six hours a day (during the lifetime of concentration) the 241-AZ-101 supernate would be concentrated 2.12 times faster (approximately 15.5 months). This operation should be monitored closely to ensure none of the Safety Limits or Limiting Conditions of Operations are violated. Another alternative would be to run the system in bypass mode, i.e. without the recirculation system operating. The tank could then be evaporatively concentrated in approximately 6 months. Finally, if the mixer pumps were to be run without the recirculation system operating 241-AZ-101 supernate could be concentrated to 5.0 M Sodium a little less than 3 months.

The present evaporation rate in tank 241-AZ-102 is not acceptable. A possible solution to allow higher evaporation rates would be to return the 702-A system to service for tank 241-AZ-102 only. The 702-AZ system would need to be valved off from the tank. Using the collected Data and calculations shows the tank can be concentrated to 5.0 M in approximately 49 months (Refer to Appendix F.5.3). Another concern is that the condensate collected at the 702-AZ system is only routed into the 241-AZ tank farm. At present, this condensate is transferred to tank 2241-102-AZ. Therefore, dilution not concentration is occurring, which leads to even longer evaporation times.

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APPENDIX E

SAMPLING SYSTEM PROCESS NEEDS AND ASSESSMENT

(Reserved)

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APPENDIX F

CALCULATIONS AND ANALYSES

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APPENDIX F

CALCULATIONS AND ANALYSES

F.1 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES OF PROCESS NEEDS PRESENTED IN TABLE 4-1

F.1.1 Sodium Removal Efficiency: Phase 1 Low Activity Waste Feed Delivery
F.1.2 Removal of Flammable Gases Retained in Waste
F.1.3 Use of Inhibited Flush Water
F.1.4 Calculation of Solids Deposition Velocity
F.1.5 Calculation of NPSHa for Mixer Pump Operation
F.1.6 Reserved
F.1.7 Reserved
F.1.8 Reserved
F.1.9 Reserved
F.1.10 Adjustment of Tanks 241-AN-102 and 241-AN-107 Waste To Meet Corrosion Specifications
F.1.11 Transfer Line Heating
F.1.12 Decant Pump Adjustable Inlet (TBP)
F.1.13 Reserved
F.1.14 Reserved
F.1.15 Reserved
F.1.16 Reserved
F.1.17 Transfer Line Flush Volumes
F.1.18 Reserved
F.1.19 Flush Water System Configuration (TBP)
F.1.20 Reserved
F.1.21 Reserved

F.2 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES FOR ADEQUACY OF WASTE PREPARATION AND TRANSFER SYSTEMS PRESENTED IN APPENDIX A

F.2.1 Calculation of Operating Transfer Rates
F.2.2 Calculation of Transfer Line Water Hammer
F.2.3 Reserved
F.2.4 Reserved
F.2.5 Reserved

F.3 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES FOR ADEQUACY OF UTILITY DISTRIBUTION SYSTEM PRESENTED IN APPENDIX B

F.3.1 Electrical Distribution System - DAPPER Model Results (To Be Produced)

F.4 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES FOR ADEQUACY OF INSTRUMENTATION, MONITORING AND CONTROL SYSTEM PRESENTED IN APPENDIX C

F.4.1 Assessment of Available Tank Camera Systems

F.5 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES FOR ADEQUACY OF VENTILATION SYSTEM PRESENTED IN APPENDIX D

F.5.1 241-AZ Farm Ventilation Thermal Analysis Model Results
F.5.2 241-AZ Farm Minimum Ventilation Flow Rate to Remove Flammable Gas (To be produced)
F.5.3 241-AZ Farm Mist Generation and Effect to Tank Vacuum During Mixer Pump Operation (To be produced)

F.6 CALCULATIONS AND ANALYSES DEVELOPED FOR THE TECHNICAL BASES FOR ADEQUACY OF SAMPLING SYSTEM PRESENTED IN APPENDIX E

F.6.1 Reserved

F.1.1 SODIUM REMOVAL EFFICIENCY:

PHASE 1 LOW ACTIVITY WASTE FEED DELIVERY

DESIGN CALCULATION

(1) Drawing N/A (2) Doc No. HNF-2938 (3) Page 1 of 5
(4) Building N/A (5) Rev. 0 (6) Job No. N/A
(7) Subject Sodium Removal Efficiency: Phase 1 Low Activity Waste Feed Delivery
(8) Originator A. B. Carlson Date 07/13/1998
(9) Checker B. B. Peters Date 8/11/1998

(10) **Objective:** Determine the percentage of sodium existing in the low-activity waste feed tanks which must be delivered in solution in order to meet low activity waste feed delivery requirements.

Design inputs:
1. Total sodium to be delivered during phase 1 privatization is 6,000 metric tons sodium calculated as Envelopes A + B + 1.15*C.
2. Initial batch will contain 300 to 600 metric tons sodium of waste and may be transferred along with the privatization contractor's feed tank
3. Additional batches shall be larger than 100 metric tons sodium.
4. Top-off transfers may occur once space is available in the private contractor's feed tank. The top-off transfers may be completed 30 days after the waste transfer date.
5. The objective is to transfer as much retrievable material from each source tank as possible during feed delivery. The minimum order quantities shall be delivered in the following sequence:

   Envelope C = 500 to 1300 metric tons sodium
   Envelope A = 750 to 1200 metric tons sodium
   Envelope C = 500 to 1300 metric tons sodium
   Envelope A = 1410 to 3700 metric tons sodium
   Envelope B = 400 metric tons sodium previously pretreated feed

Other constraints

   Envelope A + 1.15*C = 5600 metric tons sodium
   Envelope C $\leq$ 1900 metric tons sodium

6. Deliver up to 1100 metric tons sodium per year
7. Transfers shall occur no more frequently than once every 30 days per 100 metric tons of sodium delivered.
8. Envelopes A and B: maximum total organic carbon (TOC) increased to 0.5 mole TOC/mole sodium.
9. Envelopes A, B, and C: maximum aluminum increased to 0.25 mole aluminum/mole sodium.
10. Envelope A: maximum sulfate (SO_4^{-2}) increased to 0.01 mole sulfate/mole sodium.
11. For feed staging purposes only, assume that corrosion inhibitors are not added to the tanks.
12. The equivalent Cs-137 concentration in all of the transferred feed shall be less than 6 Ci/gallon.
13. Envelope A, B, and C limits only apply to the soluble fraction of the low activity waste feed.
14. The insoluble fraction for the low activity waste feed is limited to 2 wt% (dry basis).

DESIGN CALCULATION

(1) Drawing N/A (2) Doc No. HNF-2938 (3) Page 2 of 5
(4) Building N/A (5) Rev. 0 (6) Job No. N/A
(7) Subject Sodium Removal Efficiency; Phase 1 Low Activity Waste Feed Delivery
(8) Originator A. B. Carlson Date 07/13/1998
(9) Checker Date

15. The sequence of tanks, envelope,quantities and sources of available sodium are as follows:

Tank	Envelope	Quantity	Source
241-AN-107	C	620 metric tons sodium	liquid phase
241-AN-105	A	1090 metric tons sodium	entire tank
241-AN-102	C	1060 metric tons sodium	liquid phase
241-AN-104	A	1100 metric tons sodium	entire tank
241-AW-101	A	991 metric tons sodium	entire tank
241-AN-103	A	1234 metric tons sodium	entire tank
241-AP-108	B	556 metric tons sodium	entire tank

Sources:

1. Design Inputs 1-14. Taylor 1998, Letter 98-WDD-062, W. J. Taylor, RL, to R. F. Green, FDH, Contract No. DE-AC06-96RI13200 - Evaluation of Tanks Waste Disposal Second Alternative Within Privatization, May 27, 1998.
2. Design Input 15. DeLozier 1998, Letter LMHC-9854671A R1, M. P. DeLozier, Lockheed Martin Hanford Corporation, to A. M. Umek, FDH, Subonctract number 80232764-9-K001, Evaluation of Tank Waste Disposal Alternatives Within Privatization, June 15, 1998.

Assumptions:

Constituent concentrations (e.g., TOC, sulfate, aluminum, transuranic content, Cs-137) will be within the required limits for the calculated sodium retrieval efficiencies.

Computer Calculation: None

Reference: None

Calculations:

For variables let Tank 241-AN-107 be represented as C1, AN-105 as A1, AN-102 as C2, AN-104 as A2, AW-101 as A3, AN-103 as A4, and AP-108 as B1. Let retrieval efficiency = η.

Minimum retrieval efficiency is minimum order quantity divided by available sodium. Maximum retrieval efficiency is maximum order quantity divided by available sodium, however, this value can not be greater than 1.0.

DESIGN CALCULATION

(1) Drawing N/A (2) Doc No. HNF-2938 (3) Page 3 of 5
(4) Building N/A (5) Rev. 0 (6) Job No. N/A
(7) Subject Sodium Removal Efficiency: Phase 1 Low Activity Waste Feed Delivery
(8) Originator A. B. Carlson Date 07/13/1998
(9) Checker Date

$$\eta_{Tank_{min}} = \frac{Minimum\ Order\ Quantity}{Available\ Sodium} \quad (Eqn.1)$$

$$\eta_{Tank_{max}} = \frac{Maximum\ Order\ Quantity}{Available\ Sodium}\ but\ no\ greater\ than\ 1.0 \quad (Eqn.2)$$

A minimum and maximum sodium removal efficiency can be calculated for each sequential envelope of feed based on the range of the order quantity specified in design input 5 above. Note that tanks 241-AN-104, 241-AW-101, and 241-AN-103 comprise the second batch of Envelope A waste transferred to the private contractor.

$$\eta_{C1_{min}} = \frac{500\ metric\ tons}{620\ metric\ tons} = 0.806 \qquad \eta_{C1_{max}} = \frac{1300\ metric\ tons}{620\ metric\ tons} = 1.0$$

$$\eta_{A1_{min}} = \frac{750\ metric\ tons}{1090\ metric\ tons} = 0.688 \qquad \eta_{A1_{max}} = \frac{1200\ metric\ tons}{1090\ metric\ tons} = 1.0$$

$$\eta_{C2_{min}} = \frac{500\ metric\ tons}{1060\ metric\ tons} = 0.472 \qquad \eta_{C2_{max}} = \frac{1300\ metric\ tons}{1060\ metric\ tons} = 1.0$$

$$\eta_{A2+A3+A4_{min}} = \frac{1410\ metric\ tons}{1100+991+1234\ metric\ tons} = 0.424 \qquad \eta_{A2+A3+A4_{max}} = \frac{3700\ metric\ tons}{1100+991+1234\ metric\ tons} = 1.0$$

$$\eta_{B1_{min}} = \frac{400\ metric\ tons}{556\ metric\ tons} = 0.719 \qquad \eta_{B1_{max}} = \frac{400\ metric\ tons}{556\ metric\ tons} = 0.719$$

For both envelope C wastes the available sodium is based on the liquid phase portion of the tank contents. Retrieving all liquid phase sodium in the envelope C tanks is within the feed quantity limits. The minimum retrieval efficiency for envelope C waste is 0.806 based on the minimum acceptable amount of sodium to be delivered from tank 241-AN-107. For the four tanks of envelope A, retrieving all liquid and solid phase sodium is within the feed quantity limits. The minimum retrieval efficiency for envelope A waste is 0.688 based on the minimum acceptable amount of sodium to be delivered from tank 241-AN-105.

Design input 5 also states the objective is to transfer as much retrievable material from each source tank as possible during feed delivery. Therefore, greater sodium retrieval efficiency should be strived for rather than lesser sodium retrieval efficiency.

DESIGN CALCULATION

(1) Drawing N/A	(2) Doc No. HNF-2938	(3) Page 4 of 5
(4) Building N/A	(5) Rev. 0	(6) Job No. N/A
(7) Subject Sodium Removal Efficiency; Phase 1 Low Activity Waste Feed Delivery		
(8) Originator A. B. Carlson		Date 07/13/1998
(9) Checker		Date

Additional constraints exist from design input 1 & 5:

Envelope A + B + 1.15*C = 6000 metric tons sodium (Eqn. 3)
Envelope A + 1.15*C = 5600 metric tons sodium (Eqn. 4)
Envelope C ≤ 1900 metric tons sodium (Eqn. 5)

By inspection of design input 15 it is seen that the sodium content of tanks AN-107 and AN-102 is 1680 metric tons which is less than 1900 metric tons so the constraint of equation 5 is met regardless of sodium retrieval efficiency. Also, Envelope B is specifically limited to 400 metric tons sodium by design input 5, making equations 3 and 4 equivalent. Therefore a minimum average sodium retrieval efficiency can be specified for retrieval from envelope A and C tanks by the following equation:

$$\eta_{Minimum\ Average} = \frac{5600\ metric\ tons\ sodium}{1.15*C1+A1+1.15*C2+A2+A3+A4}$$

Inputing tank available sodium:

$$\eta_{Minimum\ Average} = \frac{5600\ metric\ tons\ sodium}{1.15*620+1090+1.15*1060+1100+991+1234} = 0.882$$

This minimum average is greater than the minimum sodium removal efficiency to meet the minimum envelope-specific sodium delivery quantities.

Conclusions:

The low activity waste feed minimum sodium delivery requirement to the private contractor during phase 1 privatization is 6,000 metric tons. To meet this requirement a minimum of 90 weight percent (rounded from 88.2%) of sodium: in the liquid phase in tanks 241-AN-102 and 241-AN-107; and in the solid and liquid phase in tanks 241-AN-103, 241-AN-104, and 241-AN-105, needs to be delivered to the private contractor.

DESIGN CALCULATION

(1) Drawing N/A	(2) Doc No. HNF-2938	(3) Page 5 of 5
(4) Building N/A	(5) Rev. 0	(6) Job No. N/A

(7) Subject Sodium Removal Efficiency: Phase 1 Low Activity Waste Feed Delivery

(8) Originator A. B. Carlson Date 07/13/1998

(9) Checker B. Peters Date 8/11/1998

Design Review Checklist for Design Calculation

Documents/ECNs Reviewed:

Affected Document(s):

Yes	No	NA	
[ ]	[ ]	[X]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[ ]	[ ]	[X]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[X]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivation checked including dimensionsal consistency of results.
[ ]	[ ]	[X]	Models appropriate and used within ragne of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[ ]	[ ]	[X]	Software input correct and consistent with document reviewed.
[ ]	[ ]	[X]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[X]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analyitical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards.
[ ]	[ ]	[X]*	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

Brian Peters [signature] 8/11/98

Reviewer(Printed Name and Signature) Date

F.1.2 CALCULATION OF RETAINED GAS REMOVAL NECESSARY TO AVOID A GRE EXCEEDING 25% OF THE LFL

DESIGN CALCULATION

(1) Calculation No. ____________
(2) Drawing N/A (3) Doc No. HNF-2938 (4) Page 1 of 3
(5) Building N/A (6) Calc Rev. 0 (7) Job No. N/A
(8) Subject Calculation of Retained Gas Removal Necessary to Avoid a GRE Exceeding 25% of the LFL
(9) Originator B. B. Peters Date 8/10/98
(10) Checker A. B. Carlson Date ____________

(11) **Objective:** Determine the volume of retained gas to remove from each of tanks 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, and 241-SY-103 such that a subsequent major gas release event (GRE) would not exceed 25% of the lower flammability limit (LFL) in the tank headspace.

Design Inputs:

	AN-103	AN-104	AN-105	AW-101	SY-103
Release Vol. for LFL (m3)	124	96	77	150	306
Retained Gas Vol. (m3)	363	197	148	115	150
Rel. Fraction for LFL	0.34	0.49	0.52	1.30	2.04

Data taken from Table 5.5 (pg 5.8) of Stewart, et. al. (1996) attached.

Sources:

1. Stewart, C.W., J.M. Alzheimer, M.E. brewster, G, Chen, R.E. Mendoza, H.C.Reid, C.L. Shepard, G. Terrones, September 1996, *In Situ Rheology and Gas Volume in Hanford Double-Shell Waste Tanks*, PNNL-11296, Pacific Northwest National Laboratory, Richland, Washington.
2. Stewart, C.W., 1998, Personal Communication

Assumptions:

1. Historically the maximum GRE has released about 75% of the total estimated retained gas inventory (Stewart, C.W., 1998). Assume that 25% of the maximum retained gas inventory is unavailable for release during a GRE.
2. Assume the same conditions as in Stewart et. al. (1996). That is that the tanks are at their current level and during a GRE, the released gases are uniformly mixed in the tank headspace.
3. Assume that the tank waste can be slowly and in a controlled manner "degassed" using a mixer pump or other means such that headspace flammable gas concentrations don't exceed 25% of the LFL.
4. Assume that waste retrieval would occur soon (<30 days) after degassing so that retained flammable gases couldn't build back up in the waste.

Computer Calculation: None

Reference: None

8/11/98

DESIGN CALCULATION

(1) Calculation No. ____________

(2) Drawing N/A (3) Doc No. HNF-2938 (4) Page 2 of 3

(5) Building N/A (6) Calc Rev. 0 (7) Job No. N/A

(8) Subject Calculation of Retained Gas Removal Necessary to Avoid a GRE Exceeding 25% of the LFL

(9) Originator B. B. Peters Date 8/10/98

(10) Checker A. B. Carlson Date ____________

Calculations:

1) Calculate the release volume necessary to reach 25% of the LFL.
2) Calculate the fraction of the maximum inventory which historically is not released during a maximum GRE (25% of total inventory)
3) Calculate gas volume which needs to be removed so that the waste can be retrieved without exceeding 25% of the LFL (= Maximum retained gas inventory -minus- Fraction needed to reach 25% of LFL -minus- 25% of total inventory which doesn't release during a GRE)

		AN-103	AN-104	AN-105	AW-101	SY-103
R1	Release Vol. for LFL (m^3)	124	96	77	150	306
R2	Max. Retained Gas Vol. (m^3)	363	197	148	115	150
R3	Release Vol. for 25% of LFL (m^3) [0.25 * R1]	31	24	19	38	77
R4	Vol. retained and not released (25% of max. inventory) (m^3) [0.25*R2]	91	49	37	29	38
R5	Vol. To Remove (m^3) [R2 - R3 - R4]	241	124	92	49	36

Conclusions:

An appropriate Quantitative Tank-Specific Process Need is to remove sufficient retained gas from the waste such that a GRE releasing 75% of the remaining gas would not exceed an averaged concentration of 25% of the LFL. This equates to a gas removal of 241 m^3 for AN-103, 124 m^3 for AN-104, 92 m^3 for AN-105, 49 m^3 for AW-101, and 36 m^3 for SY-103.

8/11/98

DESIGN CALCULATION

(1) Calculation No. ____________

(2) Drawing N/A | (3) Doc No. HNF-2938 | (4) Page 3 of 3

(5) Building N/A | (6) Calc Rev. 0 | (7) Job No. N/A

(8) Subject Calculation of Retained Gas Removal Necessary to Avoid a GRE Exceeding 25% of the LFL

(9) Originator B. B. Peters Date 8/10/98

(10) Checker A. B. Carlson Date ____________

Design Review Checklist for Design Calculation

Documents/ECNs Reviewed:

Affected Document(s):

Yes	No	NA	
[ ]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps
[ ]	[ ]	[ ]	Problem completely defined.
[ ]	[ ]	[ ]	Accident scenarios developed in a clear and logical manner.
[ ]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[ ]	Computer codes and data files documented.
[ ]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[ ]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[ ]	Mathematical derivation checked including dimensional consistency of results.
[ ]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[ ]	Hand calculations checked for errors. (Spreadsheet results should be treated exactly the same as hand calculations)
[ ]	[ ]	[ ]	Software input correct and consistent with document reviewed.
[ ]	[ ]	[ ]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[ ]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[ ]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[ ]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[ ]	Format consistent with appropriate NRC Regulatory Guide or other standards.
[ ]	[ ]	[ ]	Review calculations, comments and/or notes are attached.
[ ]	[ ]	[ ]	Document Approved

_______________________________________ ______________

Reviewer (Printed Name and Signature) Date

8/11/98

F.1.3 USE OF INHIBITED FLUSH WATER

FLUOR DANIEL NORTHWEST, INC.
1100 Jadwin
P.O. Box 1050
Richland, Washington 99352-1050

August 11, 1998

LMHC96W0-0006
CO-98-TWRS-384

Mr. I. G. Papp
Numatec Hanford Corporation
P.O. Box 1300
Richland, Washington 99352-1300

Dear Mr. Papp:

TASK ORDER 44-10-02, PREPARE PIPING AND INSTRUMENTATION DIAGRAMS

Response Requested By: N/A

Responds To: N/A

Enclosed are two deliverables in support of the additional work that Randy Hallum is providing. They are: 1) Dynamic Thermal Analysis of Waste Transfer Piping and 2) Review of Raw Water Versus Inhibited Water for Transfer Pipe Flushing. The letter report for use of Raw Water Versus Inhibited Water is based on reviews of existing site documents. A defensible technical justification has not yet been prepared.

Please feel free to contact Randy Hallum at 376-7089 or myself at 373-2198 if you have any questions.

Sincerely,

M. W. Manderbach

M. W. Manderbach
Project Manager

MWM:sst

Attachments (2)

LMHC9620-0006
CO-98-TWRS-384

Attachment 2

FLUOR DANIEL NORTHWEST
INTEROFFICE CORRESPONDENCE

To:	M. W. Manderbach	Date:	7/31/98
Location:	Richland, B4-57	Reference:	
From:	M. B. Palm *MBPalm*		
Location:	Richland, E6-15	Client:	
Telephone:	376-8126	Subject:	Cross-Site Transfer Line Flush

c: MBP-File/LB

References
1) Project W-058/W-028, Material of Construction Position Paper, C. Van Katwijk, June 22, 1994.
2) WHC-SD-W236A-TRP-001, Multi-Function Waste Tank Facility Corrosion Test Report (Phase 1), W.C. Carlos, Dated December 14, 1993.

This letter discusses the issue of whether to use inhibited water or raw water to flush the cross-site transfer line following waste transfer between tanks.

In 1994 a position paper, Reference 1 was written which re-evaluated the materials of construction for projects W-058/W-028 which are very similar to Project W-314. Two of the goals were to determine what would be the best piping material to use, and what should be the chemical composition of the liquids that flow within the pipe. The results of the study showed that 304L SS, which has been used for waste transfer lines since the 1950's, was confirmed to be the material of choice for the primary (inner) piping. It also reported that one of the requirements for all liquids within the storage system would be to minimize corrosion. Therefore the chemical composition requirements for the liquids flowing in the transfer piping system, whether it be tank waste or flushing liquid, would need to minimize corrosion.

Also in Reference 1, the results of past corrosion studies done at the Hanford site have indicated that corrosion in the vapor space and liquid/vapor interface zones of the waste tanks is more severe than in the waste solution (liquid) zone. In the transfer piping lines, this would occur after the waste had been transferred and the line flushed out. Any remaining flushing liquids would cause a puddling effect and a liquid/vapor interface zone. The study also pointed out that the puddling was confirmed to be a major contributor to corrosion problems such as pitting and stress corrosion cracking (SCC) in the life of the line. Since the life of the transfer-line system is intended to be 40-years, every effort needs to be made to minimize corrosion that could occur on a day to day basis. For this reason it was determined that only liquid solutions that meet the chemical

M. W. Manderbach
July 31, 1998
Page 2

composition requirements put on the liquids in the double-shell tanks are allowed in the cross-site transfer lines. Therefore, since the double-shell tank minimum chemical requirements for nitrite and hydroxide respectively are 0.01M (NaOH) and 0.01M (NaNO2) for corrosion inhibition, that should also be established as a requirement for the transfer line. Of course, the liquids flowing through the transfer piping from the tank would have the correct chemical composition for the transfer piping. The issue needing to be resolved is what chemical composition does the flush water need to be. Can the water be raw, for example (out of the tap), or does it need to be inhibited water, which would have an elevated pH level.

The summary statement of Reference 2 says that in the case of 304L SS the tendency to pit and the possibility of SCC can be effectively eliminated if the pH level in the tanks are kept above a value of approx. 10.5 and temperature is kept below approx. 60 C(140F). With this information, the minimum requirement for the flush water should be at least a pH of 10.5.

Therefore, to minimize corrosion, inhibited water rather than raw water should be used to flush the transfer line.

The requirements for flushing water to be used in carbon steel transfer lines has not been specifically defined. The requirements used for stainless steel transfer lines could also be used for carbon steel lines with the understanding that the corrosion rate for carbon steel is greater than that for stainless steel.

F.1.4 CALCULATION OF SOLIDS DEPOSITION VELOCITY

IGP Ivan G. Papp
Chemical Engineer

ANALYSIS

Page 3
Job No.
Date 12-15-97
By I.G. Papp
Checked By [signature]

For
Location
Subject Deposition Velocity

Deposition velocity represents the lowest velocity at which the system can be operated such that stable flow conditions prevail.

Relative density (S_s) = density of Solids / density of water
V_{sm} = Mean velocity at limit of deposition

At a pipe diameter of 3.068 inches and a particle diameter of 70μm the V_{sm} on the center vertical axis (fig 6.4 attached) for sand would be near or less than 1 m/s, connecting this line to the S_s of 2.2 would result in a V_{sm} on the right of or less than 1 m/s. Therefore our velocity could sustain the particle flow at (1 m/s)(3.28 ft/m) = 3.28 ft/s

Reference: Slurry Handling Design of Solid-Liquid systems, Nigel P. Brown & Nigel Heywood, Elsevier Applied Science, London, 1991

We now try to apply an alternate approach:

The terminal velocity as referenced by Calc: W-058-004, Rev 0

$$V_D = F_L'\left[2gD\left(\frac{\rho_s-\rho_L}{\rho_L}\right)\right]^{1/2}\left(\frac{d}{D}\right)^{1/6}$$

$$V_D = (4)\left[2(32.2)(.256)\left(\frac{136.84-62.2}{62.2}\right)\right]^{1/2}\left(\frac{.0028}{3.068}\right)^{1/6}$$

$$V_D = (4)(4.45)(.311)$$

$$V_D = 5.53 \text{ ft/s}$$

F_L = constant based on solid concentration
$F_L = 4$ for 30% volume solids

$g = 32.2 \text{ ft/s}^2$
$D = 3.068$ in (.256 ft) 3" sch 40
$\rho_L = 62.2 \text{ lb/ft}^3$
ρ_s = density of solids
$(2.2)(62.2) = 136.84 \text{ lb/ft}^3$

$d = 70\mu m = .0028$ in

$\frac{24{,}500 \mu m}{in}$

BEST AVAILABLE COPY

54-7200-276 (2 82)

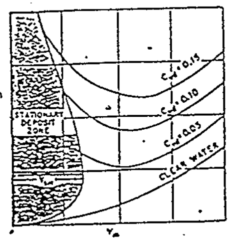


Fig. 6.3. Definition sketch for limit of stationary deposit zone.

this value ensures that deposition will not occur. The computer output shows how V_{sm} varies with internal pipe diameter, particle diameter and relative density. The effect of these variables can be expressed concisely by means of a nomographic chart (Wood, 1935; Wilson & Judge, 1978; Wilson, 1979). This chart, reproduced here as Fig. 6.4, is recommended as a practical design aid.

It should be noted, by way of explanation of the chart, that the left-hand panel

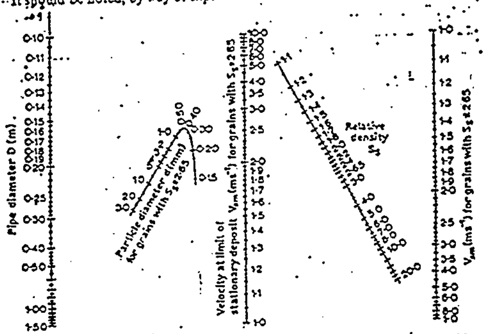


Fig. 6.4. Nomographic chart for maximum velocity at limit of stationary deposition. (Adapted from Wilson, 1979.)

IGP Ivan G. Papp
Chemical Engineer

ANALYSIS

Page 5
Job No.
Date 12-15-97
By I G Papp
Checked By [signature]

For
Location
Subject

If we are to apply some margin of safety to our deposition velocity a typical value would be 1.3 times our calculated value. This would equate to a 30% safety margin. We then have:

$(1.3)(5.53\ ft/s) = 7.2\ ft/s$

By review of the previously released "Process Design Guides" SD-RE-PDG-001 (RHO), we find guidance in section 5 for slurry transfers.

This guidance calls for fluids containing solids to be transferred at a velocity between 6-9 ft/s as "reasonable".

The velocity we determined above (7.2 ft/s) falls within this range. It may be noted that the range of velocities was developed from operational experience gained by Hanford transfer operations.

BEST AVAILABLE COPY

54-7400-276 (2 88)

F.1.5 CALCULATION OF NPSHa FOR MIXER PUMP OPERATION

Evaluation of Minimum Submergence required to prevent Cavitation in transfer pump.

Assumptions:

- Sulzer-Bingham Transfer Pump. see attached pump curve.
- Transfer occurs at 140 gallons per minute.
- SpG of Waste = 1.41
- Vapor pressure of Waste = Water (this is conservative)

We wish to draw the waste in the tanks down to 10".
What is the maximum temperature at which that is possible?
From pump curve @ 140 GPM NPSHR ≅ 18 ft.

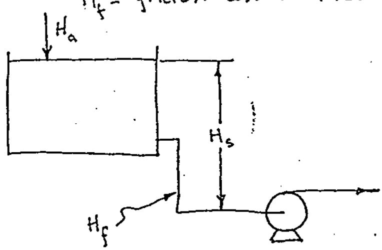
$$NPSHA = H_s + H_a - H_{vap} - H_f$$

H_s = Static Head

H_a = atmospheric pressure Head

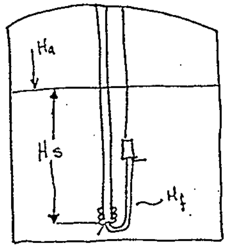
H_{vap} = Vapor pressure of Liquid

H_f = friction loss in Intake piping



(1.)

or in our tanks



the length of the flex line from the pump to the intake is ~ 20ft.

for a flow rate of 150 gpm the friction loss in 3" schedule 40 pipe is 2.24 $\frac{lb}{in^2}$ per 100ft

reference CRANE Technical paper No. 410

Flow of Fluids through Valves, Fittings, and Pipe.

As a Conservative estimate assume that the friction loss through the flex line is ~ 2.5 psi

converting to Head $2.5\,psi \times \frac{33.9\,ft}{14.7\,psi} = 5.8\,ft.$

$H_f \approx 6\,ft$

H_a — Maximum Elevation in the transfer line is 690ft.

$$\frac{\rho_{air}}{\rho_{water}} = \frac{\text{Height of Water Column}}{\text{Height of Air Column}}$$

at sea level standard pressure is 1 atm. or 33.9ft water

$\rho_{air} = 0.0752\ lb/ft^3$

$\rho_{water} = 62.4\ lb/ft^3$

$$\text{Height of Air Column} = \frac{(33.9\ ft\ H_2O)(62.4\ lb_m/ft^3\ H_2O)}{0.0752\ lb_m/ft^3\ air}$$

$$= 28{,}130\ ft\ air$$

(2)

Now Adjusting for elevation, and negative pressure in the tank,

Assume: tank pressure is -4 in W.G.

first adjusting for elevation

28,130 − 690 = 27,440 ft air

now converting into ft H_2O

$$27{,}440 \text{ ft air} \times \frac{33.9 \text{ ft } H_2O}{28{,}130 \text{ ft Air}} = 33.1 \text{ ft } H_2O$$

Now Adjusting for the negative pressure in the tank

33.1 ft H_2O − .33 ft H_2O = ~~32.8 ft H_2O~~ 32.7 ft H_2O

the maximum Allowable temperature in the Tank is 195°F

@ 195°F the vapor pressure of water is ~ 10.4 psi

converting to ft H_2O

$$10.4 \text{ psi} \times \frac{33.9 \text{ ft } H_2O}{14.7 \text{ psi}} = 24 \text{ ft } H_2O$$

There fore at the maximum allowable temperature, where NPSHA = NPSHR

$$H_{s_{min}} = NPSHR + H_{VAP} + H_f - H_a$$

$$= 18 \text{ ft} + 24 \text{ ft} + 6 \text{ ft} - 32.7 \text{ ft}$$

$$= 15.3 \text{ ft}$$

Adjusting for a SpG of 1.41 yields

~ 11 ft of Submergence (3.)

At the maximum allowable tank temperature, we will not be able to draw the tank down to 10 in.

At what temperature can the tank be drawn down to 10"

$H_{vap} = H_s + H_a - H_f - NPSHR$

from PROJ. W-211 drawings bottom of tank to first impeller is 27 in. With the tank drawn down to 10 in., $H_s = -17$ in
$= -1.4$ ft

Adjusting for SpG = 1.41
$H_s = -2.0$ ft H_2O

$H_{VAP} = -2.0 + 32.7 - 6 - 18$
$= 6.7$ ft H_2O

Converting to psi

$$6.7 \text{ ft } H_2O \times \frac{14.7 \text{ psi}}{33.9 \text{ ft } H_2O} = 2.9 \text{ psi}$$

from Combustion Engineering Steam Tables
Maximum Temperature allowable is 140°F

(4.)

F.1.10 ADJUSTMENT TO TANKS 241-AN-102 AND 241-AN-107 WASTE TO MEET CORROSION SPECIFICATIONS

DESIGN CALCULATION

(1) Drawing N/A (2) Doc No. HNF-2938 (3) Page 1 of 2
(4) Building 241-AN (5) Rev. 0 (6) Job No. N/A
(7) Subject Caustic Needs for 241-AN-102 and 107
(8) Originator W.L. Willis [signature] Date 10/06/1998
(9) Checker A.B. Carlson [signature] Date 10/06/1998

(10) **Objective:** Determine the minimum volume of 19 M NaOH necessary to bring the supernatant waste in 241-AN-102 and 107 into compliance with the corrosion specification.

Design Inputs:

1. The supernatant volumes in the tanks are as follows (Hanlon 1998):

   - 241-AN-102 3,700,000 liters (978,000 gallons)
   - 241-AN-107 3,030,000 liters (801,000 gallons)

2. The volume of each tank corresponds to approximately 410,000 l per meter (2750 gal/in.) of tank depth.

3. The corrosion specification is as follows (OSD 1998):

for $[NO_3^-] \leq 1.0$ M;	$0.010\ M \leq [OH^-] \leq 5.0\ M$, $0.011\ M \leq [NO_2^-] \leq 5.5\ M$, $[NO_3^-]/([OH^-] + [NO_2^-]) < 2.5$
for $1.0M < [NO_3^-] \leq 3.0$ M;	$0.1\ ([NO_3^-]) \leq [OH^-] < 10M$, $[OH^-] + [NO_2^-] \geq 0.4\ ([NO_3^-])$
for $[NO_3^-] > 3$ M;	$0.3\ M \leq [OH^-] < 10\ M$, $[OH^-] + [NO_2^-] \geq 1.2\ M$, $[NO_3] \leq 5.5\ M$

4. Tank Supernatant concentrations for 241-AN-102 are as follows (Herting 1998):

   $[OH^-]$ - 0.22 M $[NO_2^-]$ - 1.71 M $[NO_3^-]$ - 3.74 M

5. Caustic demand for supernate in tank 241-AN-107 is 0.39 l per liter of supernate (Herting 1995).

Assumptions:

1. The supernatant liquid will be retrieved down to within 0.25 m (10 in.) of the solids layer in each tank

Reference:

Hanlon 1998, *Waste Tank summary Report for Month ending June 30, 1998*, HNF-EP-0182-123, Fluor Daniel Hanford Corporation, Richland Washington

OSD 1998, *Tank Farms Operating Specification Document*, OSD-T-151-00007, Rev. H-21, released 9/29/98, Lockheed Martin Hanford Corporation, Richland Washington

Herting 1994, *Process Aids 1994*, WHC-IP-0711-26, Westinghouse Hanford Company, Richland Washington

Herting 1995, *Process Aids 1995*, WHC-IP-0711-27, Westinghouse Hanford Company, Richland Washington

Calculations:

1. Based on design inputs 3 and 4 above, the minimum required OH^- concentration to meet corrosion specifications for 241-AN-102 is 0.3 M. We need to solve the following equation to determine the necessary volume of caustic to add to Tank 241-AN-102.

$$A \times M + X \times N = (A+X) \times Q \quad (1)$$

Where:

A = supernate volume to be transferred   M = supernate concentration $[OH^-$ or $OH^- + NO_2^-]$ X = volume added caustic solution
N = caustic solution concentration $[OH^-]$ Q = desired concentration $[OH^-$ or $OH^- + NO_2^-]$

DESIGN CALCULATION

(1) Drawing N/A	(2) Doc No. HNF-2938	(3) Page 2 of 2
(4) Building 241-AN	(5) Rev. 0	(6) Job No. N/A
(7) Subject Caustic Needs for 241-AN-102 and 107		
(8) Originator W.L. Willis		Date 10/06/1998
(9) Checker A.B. Carlson		Date 10/06/1998

Rearranging yields the following:

$$A \times M + X \times N = A \times Q + X \times Q$$
$$A \times M - A \times Q = X \times Q - X \times N$$
$$A \times M - -A \times Q = X \times (Q - N)$$

Solving for X yields:

$$X = \frac{(A \times M - A \times Q)}{(Q - N)} \qquad (2)$$

For Tank 241-AN-102 in order to meet the [OH$^-$] requirement for waste with > 3 M [NO_3^-], the following apply (Herting 1994):

A = 3,700,000 l - 103,000 l = 3,600,000 l M = 0.22 M N = 19 M Q = 0.30 M

Solving for X in equation 2 above yields 15,400 l (4100 gal) 19 M NaOH as a minimum volume to be added to Tank 241-AN-102 supernatant to comply with the corrosion specification.

2. Based on design input 5 above, we can determine the volume of caustic needed in Tank 241-AN-107 as follows:

(3,030,000 liters supernate - 103,000 liters supernate remaining in tank) X 0.039 liters 19 M NaOH / liter supernate = 114,000 liters 19 M NaOH

Conclusions:

At a minimum, 15,400 l (4100 gal) of 19 M NaOH would need to be added to the supernatant in Tank 241-AN-102 to comply with the corrosion specification in the receiving tank.

At a minimum, 114,000 l (30,200 gal) of 19 M NaOH would need to be added to the supernatant in Tank 241-AN-107 to comply with the corrosion specification in the receiving tank.

F.1.11 TRANSFER LINE HEATING

FLUOR DANIEL NORTHWEST, INC.
1100 Jadwin
P.O. Box 1050
Richland, Washington 99352-1050

August 11, 1998

LMHC96W0-0006
CO-98-TWRS-384

Mr. I. G. Papp
Numatec Hanford Corporation
P.O. Box 1300
Richland, Washington 99352-1300

Dear Mr. Papp:

TASK ORDER 44-10-02, PREPARE PIPING AND INSTRUMENTATION DIAGRAMS

Response Requested By: N/A

Responds To: N/A

Enclosed are two deliverables in support of the additional work that Randy Hallum is providing. They are: 1) Dynamic Thermal Analysis of Waste Transfer Piping and 2) Review of Raw Water Versus Inhibited Water for Transfer Pipe Flushing. The letter report for use of Raw Water Versus Inhibited Water is based on reviews of existing site documents. A defensible technical justification has not yet been prepared.

Please feel free to contact Randy Hallum at 376-7089 or myself at 373-2198 if you have any questions.

Sincerely,

M. W. Manderbach

M. W. Manderbach
Project Manager

MWM:sst

Attachments (2)

LMHC9620-0006
CO-98-TWRS-384

Attachment 1

MEMO

To: Mark Manderbach
From: Ed Smith
Subject: Heat Up/Heat Loss Through Routes
Date: August 6, 1998

The attached report contains a dynamic thermal analysis of the Hanford waste transfer double buried pipe.

The analysis was performed using AspenTech's Speedup computer modeling program. Two cases were considered for the waste transfer with differing assumptions made for the initial waste temperature and surrounding soil/pipe temperatures.

The results of the analysis show that the transfer pipe will heat up from it's initial temperature to nearly waste temperature over a very short period of time. It also shows the steady state temperature will be within a few degrees of the waste's initial temperature but that it will take a period much greater than twenty-four hours to reach this state as the soil takes a long time to heat up.

Fluor Daniel
Computer Solutions

Hanford Buried Pipe Dynamic Simulation Thermal Analysis

Initial Report

4 August 1998

Summary

Fluor Daniel Applied Computer Solutions (ACS) has completed a dynamic simulation analysis of the Hanford double buried pipe. The pipe design includes a 3" inch inner pipe and a 6" outer pipe. The annular space between the pipe contains air. The objectives of the simulation are to:

- Determine outlet fluid temperature at steady state conditions
- Determine time required to heat the pipe to steady state conditions

Cases

Two Cases were considered. The following table summarizes the two simulation cases.

	Case 1	Case 2
Fluid Temperature (°F)	200	104
Fluid Velocity (ft./sec)	6	6
Pipe Length (ft.)	4007	4007
Soil Temperature (°F)	50	33.5

The initial conditions for both cases are zero flow with the pipe at the ambient soil temperature.

Case 1 is the same conditions as reference calculation W314-P-006 dated Mar 12 1998 by Fluor Daniel Northwest.

Dynamic Model

The model includes the following assumptions:

- The line is broken into 10 segments.
- The fluid is assumed to be water.
- Heat transfer from the fluid to the 3" pipe wall in each segment is based on the equation for heat transfer for turbulent flow:

$$Nu = 0.023\, Re^{0.8} Pr^{0.3}$$

- Heat transfer in the annular space between the pipes is based on natural convection and radiation per the reference calculation. Natural convection uses the equation:

$$Nu = 0.19\, Gr^{0.25}$$

- The model neglects the thermal conductivity in the pipe wall (infinite conductivity). The pipe material is assumed to be carbon steel.
- The soil surrounding each segment is broken into 50 concentric rings for heat transfer and heat capacitance calculations. The soil heat transfer is based on conduction with conductivity and heat capacitance based on dry sand. The soil temperature is assumed to be constant at a five foot radius from the center of the pipe
- AspenTech's Speedup program was used to perform the analysis. The model is linked to *Aspen Plus for physical properties of water.*

The Speedup model developed for this study is appended to the report.

Results

Results for each case are attached to this report and are summarized by the following table.

	Case 1		Case 2	
	At 24 minutes	>> 24 hours	At 30 minutes	>> 24 hours
Fluid Temperature Loss (°F)	10	2.7	2	0.6
Fluid and Inner Pipe Wall Temperature (°F)	190	197	102	103
Outer pipe Temperature (°F)	46	149	55	84

Speedup was run in dynamic mode for the results at 24 and 30 minutes and in steady state mode for the results greater than 24 hours. An extended dynamic run for Case 1 indicated that the pipe still had not reached steady conditions after 40 hours.

Case 1

The fluid temperature reaches a new value of 190 °F (88 °C), 24 minutes after the start of flow. However, the fluid does not reach its final steady state value of 197 °F (92 °C) at a time much greater than 24 hours as the soil takes a long time to heat up. Figure 1 shows the temperatures for the *fluid, inner pipe, outer pipe, and three layers of soil one inch thick each* closest to the outer pipe. Figure 1a is a close-up of the fluid temperature.

Case 2

The fluid temperature reaches a new value of 102 °F (39 °C), 30 minutes after the start of flow and reaches its final steady state value of 103 °F (39.4 °C) at a time greater than 24 hours. Figure 1 shows the temperatures for the fluid, inner pipe, outer pipe, and three layers of soil one inch thick closest to the outer pipe. Figure 1a is a close-up of the fluid temperature.

AUG 04 1998 17:40 FR FLUOR DANIEL ACS 949 975 5856 TO 1915093736471 P.03/13

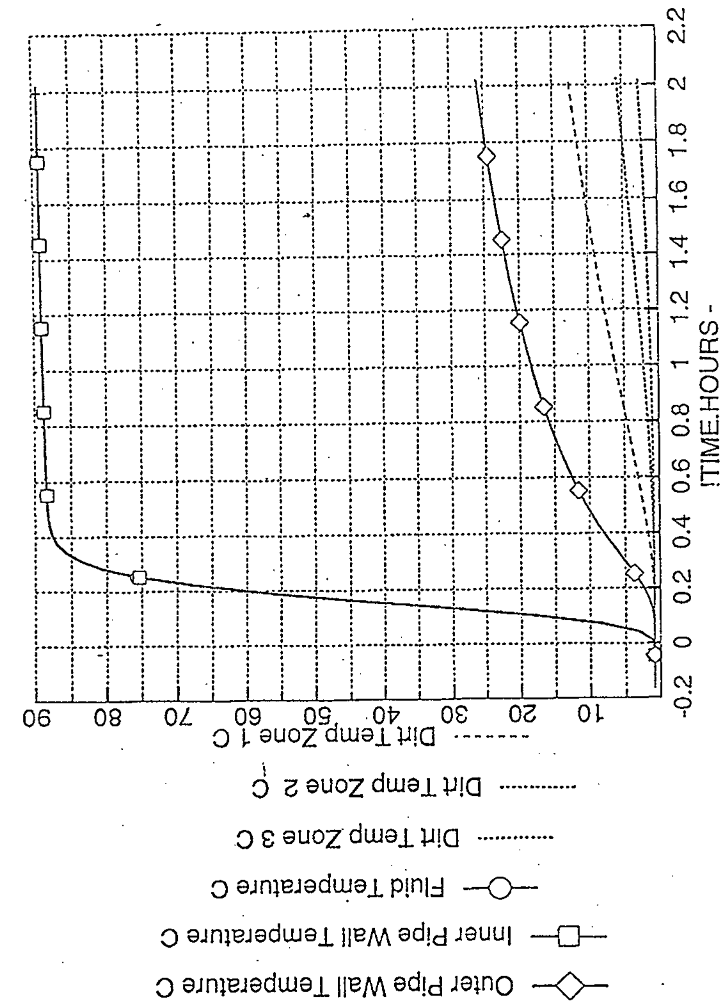


Figure 1 - Temperatues at end of pipe (Case 1)

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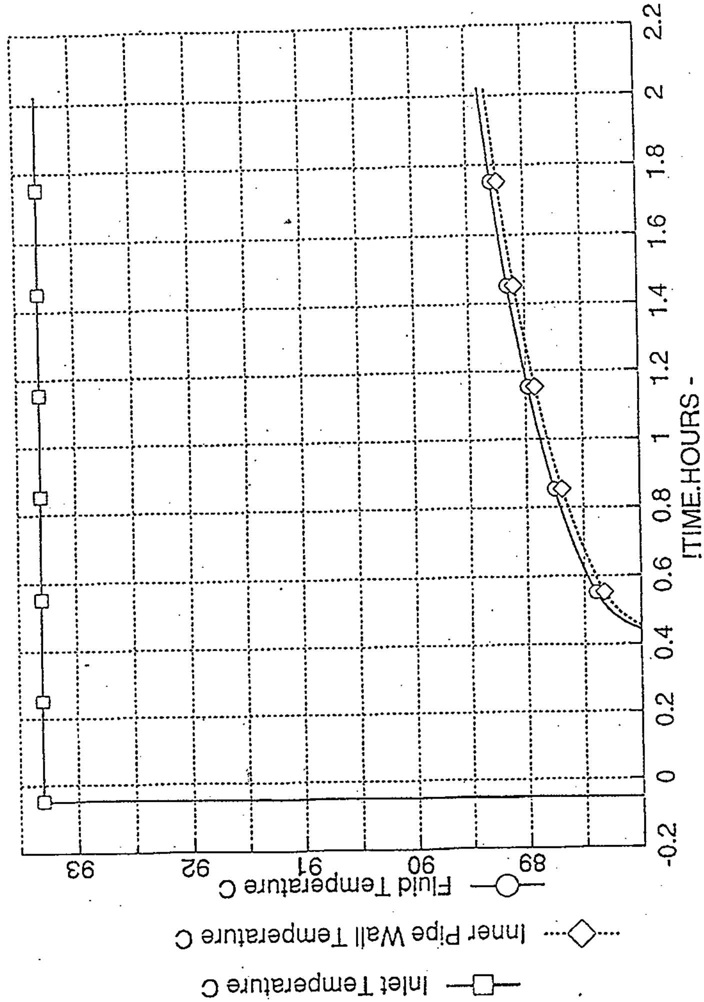
Figure 2 - Temperature Close-up (Case 1)



AUG 04 1998 17:41 FR FLUOR DANIEL ACS 949 975 5856 TO 1915093736471 P.05/13

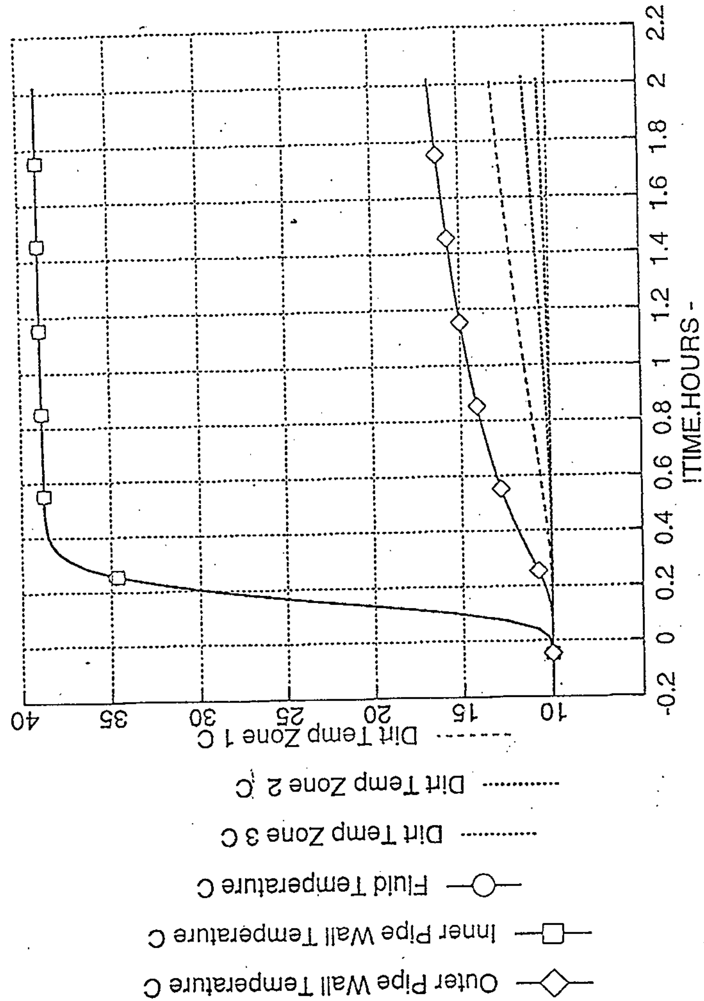


Figure 1 - Temperatues at end of pipe (Case 2)

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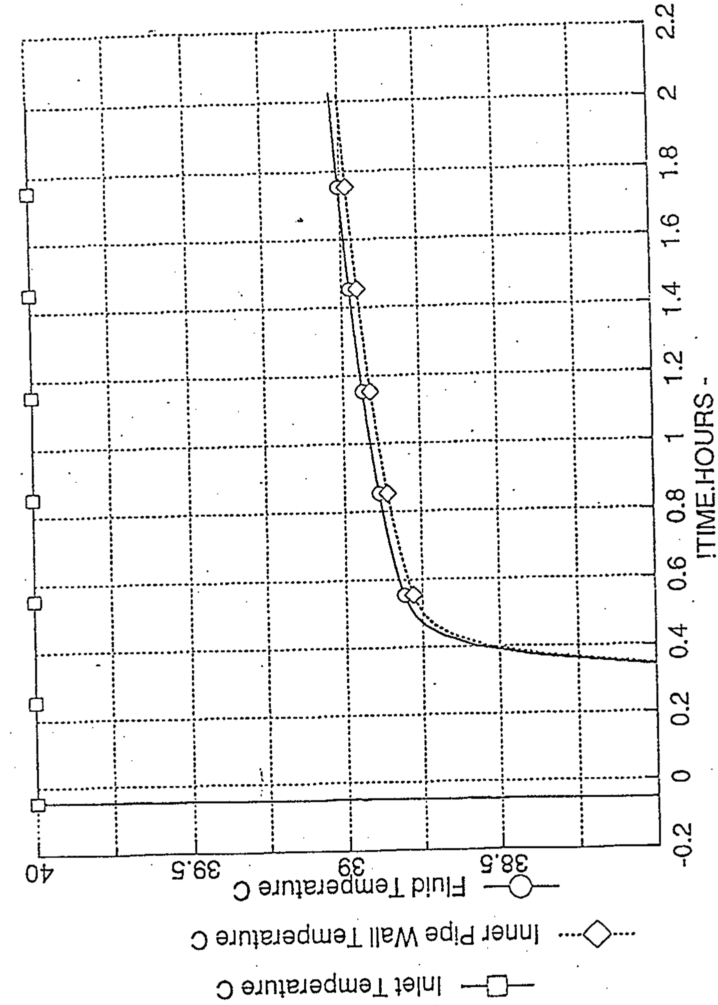

Figure 2 - Temperature Close-up (Case 2)

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```
MODEL TPIPEDW

{

Hanford

   -  Double pipe
   -  radiation and natural convection from inner pipe to outer pipe
   -  only set spgr=1, model adjustment for heavier fluids with solids has
      not been completed and tested.

   length      =                     { pipe actual length - m }
   eq_len      =                     { pipe equivalent length - m }
   diam_i1     =                     { pipe inside diameter - m }
   thick_p1    =                     { pipe thickness - m }
   dens_p      =                     { pipe material density - kg/m3 }
 # k_p         =                     { pipe conductivity - W/m-K }
   emm         =                     { radiation emissivity (0.9) }

Notes

   requires procedure cp_mol_liq

   Thermal Pipe model to calculate wall temerature
   Text Process many segments together

}

?set zero_flow=0   ?end  # try not using anymore
?set nrings=50     ?end  # number of rings of dirt
SET

   NOCOMP_H2O       = 1           # number of components
   V_CP_TO_NSM2     = 1.0E-3,     # (N-S/M2) / cP
   V_GRAVITY        = 9.81,       # m/s2
   V_HR_TO_SEC      = 3600.0,     # s / hr
   V_KJ_TO_GJ       = 1.0E-6,     # GJ / kJ
   V_J_TO_GJ        = 1.0E-9,     # GJ / J
   V_MM_TO_M        = 1.0E-3,     # m / mm
   V_NEG            = -1.0E10,    # minus infinity (ish)
   V_ONE            = 1.0,        #
   V_POS            = 1.0E10,     # plus infinity (ish)
   V_W_TO_GJHR      = 3.6E-6,     # (GJ/hr) / W
   V_ZERO           = 0.0,        #
   V_PI             = 3.14159,
   V_M2_TO_FT2      = 10.75,      # ft2/m2
   V_BTUHRFT2F_TO_WM2K =  5.666      # (W/m2-K) / (Btu/hr-ft2-F)
   V_KCALH_TO_W     =  1.162,        # W/kcal/h)
   V_KM_TO_M        =     1.0E+3,    # M / KM
   FF_CONV          =     0.010125
   FF_POWER         =    -0.217,
   V_MIN_DIAM       =     0.00001    # Minimum diam for power linearisation
   V_SM_DIAM        = 0.1384         # Diam to switch correlations
   V_LG_DIAM        = 0.1410         # Diam to switch correlations
   SB_CONST         = 5.675E-8       # stephan bolzman constant
                                     # 0.1714e-8 Btu/ft2-hr-R4 (5.67e-8 W/m2-K4)

 # Air properties

   CP_A             =  *1007         # heat capacity of air, J/kg-K
   KVISC_A          =  *1.93E-5      # kinematic visc of air, m2/s
   K_A              =  *0.02537      # conductivity of air, W/m-K
   BETA             =  0.003225      # Thermal Expansion p6/13 0.00179/R *492/273

 #
 # Dirt Properties (dry sand)
```

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```
#
  CP_D          =  837          # heat capacity, 0.2 BTU/LB/F = 837 J/kg-K
  K_D           =  0.33         # conductivity, 0.19 Btu/F-ft-hr = 0.33 W/m-K
  DENS_D        =  1600         # density, 100 LBM/FT3 = 1600 KG/M3

TYPE
#
#   Input F1:
#
  F_in            AS        flow_mol
  P_in            AS        pressure
  h_in_f          AS        enth_mol
  h_in_r          AS        enth_mol
#
#   Output P1:
#
  F_out           AS        flow_mol
  P_out           AS        pressure
  h_out_f         AS        enth_mol
  h_out_r         AS        enth_mol
#
#   Internal Flash
#
  T               AS        temperature      # Temperature for enthalpy calculation
  P               AS        pressure         # Pressure passed to downstream unit
  F_mass          AS        flow_mass        # Mass flowrate

#
#  Constants in property correlations:
#
  MWC           AS ARRAY (NOCOMP_H2O)
                   OF  loprop               # Component molecular weights
  AHL           AS ARRAY (NOCOMP_H2O)
                   OF  loprop               # Liquid enthalpy 'A' coefficents
  BHL           AS ARRAY (NOCOMP_H2O)
                   OF  loprop               # Liquid enthalpy 'B' coefficents
  AVL           AS     loprop               # Liquid specific volume 'A' coeff
  BVL           AS     loprop               # Liquid specific volume 'B' coeff

 *diam_i1             as length            # m  - pipe inside diamter
  diam_o1             as length            # m
 *thick_p1            as length            # m

 *diam_i2             as length            # m  - pipe inside diamter
  diam_o2             as length            # m
 *thick_p2            as length            # m

 *diam_d              as length            # m  - pipe inside diamter
  thick_d             as length            # m
?repeat
  diam_d?(i)          as length            # m
  q_d?(i)             as heat_flow         # GJ/hr
  t_d?(i)             as temperature       # C
  mass_d?(i)          as mass              # kg
  area_d?(i)          as area              # m2
  E_d?(i)             as energy            # GJ
?with i=<1:nrings>
  q_d?(nrings+1)      as heat_flow         # GJ/hr
  diam_d?(nrings+1)   as length            # m
  area_d?(nrings+1)   as area              # m2

 *length             as length             # m

#*k_p                 as notype              W/m-K
 *dens_p              as dens_mass         # kg/m3
# cp_p                as notype              kJ/kg-K
```

```
 vel                      as velocity          # m/s
 vel_km                   as velocity          # km/s
 vel_sqrd                 as notype            # Velocity in pipe squared
 k_l                      as cond_liq          # Liq Conductivity, W/m-K
 visc_l                   as visc              # cP
 cp_l                     as cp_mol            # KJ/kgmol-K
*rho_mol                  as dens_mol          # kgmol/m3
 rho_mass                 as dens_mass         # kg/m3
*spgr                     as notype

 dP_frict        AS       press_diff           # Pressure change due to friction
 fric_fact       AS       notype               # Friction factor

 dt.dt_x                  as notype            #  Deg C

# u_amb                   as heat_trans_coeff    W/m2-K
 htc_lp                   as heat_trans_coeff  # W/m2-K
 htc_lp_t                 as heat_trans_coeff  # W/m2-K
 htc_ppc                  as heat_trans_coeff  # W/m2-K
 htc_ppc_t                as heat_trans_coeff  # W/m2-K
 coef                     as positive
*eq_len                   as length

 q_lp                     as heat_flow         # GJ/hr
 q_ppc                    as heat_flow         # GJ/hr
 q_ppr                    as heat_flow         # GJ/hr
#  q_pd                   as heat_flow

 T_l                      as temperature       # C
 T_p1                     as temperature       # C
 T_p2                     as temperature       # C

 mass_p1                  as mass              # kg
 mass_p2                  as mass              # kg

 area_flow                as area              # m2
 area_lp                  as area              # m2
 area_ppc                 as area              # m2
 area_ppr                 as area              # m2
#  area_pd                 as area               m2

 E_p1                     as energy            # GJ
 E_p2                     as energy            # GJ
 E_l                      as energy            # GJ

 Re, Pr, Nu               as notype
 Re_exp, Pr_exp           as notype

 low_flow                 as fraction

* emm                     as notype
 T_amb                    as temperature       # ambient temp set in set_globals

#
# Air Natural Convection
#

 Nu_a                     as notype            # Air Prandlt
 Gr_a                     as notype            # Air Grashoff
 Gr_25                    as notype
 dens_a                   as dens_mass
 del                      as length

 h2o_dummy      AS   ARRAY ( 1 )              # Dummy water/steam composition vector
                     OF molefraction          #
```

```
STREAM
    INPUT   F1    F_in,  P_in,  h_in_f,  h_in_r
    OUTPUT  P1    F_out, P_out, h_out_f, h_out_r

EQUATION
#-----------------------------------------------------------
#
# Pressure drop relationships with flow and elevation change
#

  P_out       = P_in - dP_frict ;
  dP_frict * Diam_i1
              =   fric_fact * FF_CONV * Eq_Len * vel_sqrd / 2
                * rho_mass * 10 ;
  area_flow = (V_PI/4)*(diam_i1*diam_i1) ;
  vel * rho_mass * area_flow = f_mass / V_HR_TO_SEC  ;

#-----------------------------------------------------------
#
# Miscellaneous
#
  F_in    = F_out ;
  h_in_r = h_out_r ;
  vel_km = vel / 1000;
  h2o_dummy( 1 ) = 1 ;
  P_out = P ;
  T_l   = T ;

# rho_mol   = 1.0 / (AVL + BVL * T) ;
  rho_mass = rho_mol * MWC(1) * spgr ;
  F_mass    = F_out * MWC(1) * spgr ;

#-----------------------------------------------------------
#
# Geometry Data
#

  diam_o1    = diam_i1 + 2*thick_p1 ;
  diam_o2    = diam_i2 + 2*thick_p2 ;

  mass_p1    = dens_p * length *
            (V_PI/4)*(diam_o1*diam_o1 - diam_i1*diam_i1) ;
  mass_p2    = dens_p * length *
            (V_PI/4)*(diam_o2*diam_o2 - diam_i2*diam_i2) ;

#-----------------------------------------------------------
#
# Forced convection from liq to pipe
#

  Re   * visc_l * V_CP_TO_NSM2 = diam_i1 * vel * rho_mass ;
  Pr   * k_l * MWC(1) * spgr = cp_l * visc_l ;
  Nu   * k_l      = htc_lp_t * diam_i1 ;
# The following correlation is for Warm Gas to Cold Horizontal Pipe
# Nu = 0.023 * Re'0.8 * Pr'0.3 ;
  Nu = 0.023 * Re_exp * Pr_exp ;
  area_lp    = length * V_PI * diam_i1   ;
  q_lp =low_flow * htc_lp * area_lp * (T_l - T_p1 ) * V_W_TO_GJHR  ;

#-----------------------------------------------------------
```

```
#
# Liq Heat balance
#
?if zero_flow=1 ?then
  h_in_f = h_out_f ;
?else
# q_lp   = f_in * (h_in_f - h_out_f ) ;
  SE_l   = f_in*h_in_f - f_out*h_out_f - q_lp ;
?endif
  E_l    = h_out_f * rho_mol * length * area_flow ;

# E_l    = h_out_f * length * area_flow * 1000 / MWC(1) / spgr ;

#--------------------------------------------------------------
#
# Radiant from inner pipe to outer pipe
#
# stephan bolzman 0.1714e-8 Btu/ft2-hr-R4 ( = 5.67e-8 W/m2-K4 )

  area_ppr    = length * V_PI * diam_o1 ;

  q_ppr = emm * SB_CONST * area_ppr *
      ((T_p1+273)*(T_p1+273)*(T_p1+273)*(T_p1+273) -
        (T_p2+273)*(T_p2+273)*(T_p2+273)*(T_p2+273)) * V_W_TO_GJHR ;

#--------------------------------------------------------------
#
# Air Natural Convective from pipe to ambient
# page 7/13 of calc w314-p-006

  dt_x = T_p2 - T_p1   ;
  dens_a = 1.132 ;
  del    = ( diam_i2 - diam_o1 ) / 2;

  Gr_a = dens_a'2 * V_GRAVITY * BETA * dt * del'3 / kvisc_a / kvisc_a;
  Nu_a = 0.195 * Gr_25;

  htc_ppc_t = Nu_a * k_a / del ;

  area_ppc    = length * V_PI * ( diam_o1+diam_i2)/2;

  q_ppc = htc_ppc * area_ppc * (T_p1 - T_p2) * V_W_TO_GJHR   ;
#--------------------------------------------------------------
#
# Conduction in dirt

  thick_d   = (diam_d - diam_o2) / 2 / ( ?(nrings)+1);

  diam_d1 = diam_o2 + 1*2*thick_d ;
  area_d1 = length * V_PI * (diam_d1 + diam_o2) / 2 ;
  q_d1    = (k_d/thick_d) * area_d1 * (T_p2-T_d1) * V_W_TO_GJHR ;

  mass_d1 = dens_d * length *
            (V_PI/4)*(diam_d1*diam_d1 - diam_o2*diam_o2) ;
  E_d1    = mass_d1 * Cp_d * (T_d1+273) * V_J_TO_GJ ;
 SE_d1    = q_d1 - q_d2   ;

 ?repeat
   diam_d?(i) = diam_o2 + ?(i)*2*thick_d ;
   area_d?(i) = length * V_PI * (diam_d?(i) + diam_d?(i-1)) / 2 ;
   q_d?(i)    = (k_d/thick_d) * area_d?(i) * (T_d?(i-1)-T_d?(i)) * V_W_TO_GJHR ;
```

```
  mass_d?(i) = dens_d * length *
               (V_PI/4)*(diam_d?(i)*diam_d?(i) - diam_d?(i-1)*diam_d?(i-1)) ;
  E_d?(i)   = mass_d?(i) * Cp_d * (T_d?(i)+273) * V_J_TO_GJ ;
  $E_d?(i)  = q_d?(i) - q_d?(i+1)   ;

?with i=<2:nrings>

  diam_d?(nrings+1) = diam_o2 + ?(nrings+1)*2*thick_d ;
  area_d?(nrings+1) =
       length * V_PI * (diam_d?(nrings+1) + diam_d?(nrings)) / 2 ;
  q_d?(nrings+1) =
      (k_d/thick_d) * area_d?(nrings+1) * (T_d?(nrings)-T_amb) * V_W_TO_GJHR ;

( area_pd  = length * V_PI * ( diam_o2+diam_d)/2 ;
  thick_d  = (diam_d - diam_o2) / 2              ;
  q_pd = (k_d/thick_d) * area_pd * ( T_p2 - T_amb ) * V_W_TO_GJHR ; )

#--------------------------------------------------------------
#
# Conduction through pipe wall
#
# pipe is assumed to have a constant temperature throughout
#
#--------------------------------------------------------------
#
# Pipe Dynamics
#
  $E_p1  =    q_lp - q_ppc - q_ppr ;

  $E_p2  =    q_ppc + q_ppr - q_d1 ;

# fudged mole weight of steel (Fe) of 50 go give Cp=.5 at 295 K
# Cp = 4.13 + 0.00638*T

  E_p1 * 50.3 =  mass_p1 * (
                          4.13*(T_p1+273)
                        + 0.00638 *(T_p1+273)*(T_p1+273)/2
                            ) * 4.183 * V_KJ_TO_GJ ;

  E_p2 * 50.3 =  mass_p2 * (
                          4.13*(T_p2+273)
                        + 0.00638 *(T_p2+273)*(T_p2+273)/2
                            ) * 4.183 * V_KJ_TO_GJ ;


#
#-------------------------------------------------------
#

PROCEDURE

  ( vel_sqrd ) signed_square ( vel_km )

  ( htc_lp  )   copy_1 (htc_lp_t  ) TEAR
  ( htc_ppc )   copy_1 (htc_ppc_t ) TEAR

  ( k_1     )  cond_liq     ( T, P, h2o_dummy )  INPUT F1, TEAR
  ( cp_1    )  cp_mol_liq   ( T, P, h2o_dummy )  INPUT F1, TEAR
  ( visc_1  )  visc_liq     ( T, P, h2o_dummy )  INPUT F1, TEAR

  ( dt )       abs     (dt_x )
  ( low_flow ) limit   (f_in,  V_ZERO, V_ONE )

  ( Re_exp )   power   ( Re, 0.80, 2100.        )
  ( Pr_exp )   power   ( Pr, 0.30, 0.01         )
```

```
( gr_25    )  power  ( gr_a, 0.25,  10000.  )
( coef     )  ramp   ( Diam_o1, V_SM_DIAM, V_LG_DIAM, V_ZERO, V_ONE )

#
# Friction factor
#
  ( fric_fact )  power (Diam_i1,FF_POWER,V_MIN_DIAM)

# Flash
  ( h_out_f       )  prop_calc_hl   ( T, h2o_dummy,  AHL, BHL )

  ( MWC,
    AHL, BHL,
    AVL, BVL      )  prop_corr_lhd  ( T, P, h2o_dummy      ) INPUT F1, TEAR

 ( T_amb)            get_param      ( "TAMB" )
```

F1.1.17 TRANSFER LINE FLUSH VOLUMES

DESIGN CALCULATION

(1) Drawing N/A (2) Doc No. HNF-2838 (3) Page 1 of 1
(4) Building 241-AN Farm (5) Rev. 0 (6) Job No. N/A
(7) Subject Transfer Line Flush Volume
(8) Originator T. R. Benegas [signature] 10/1/98 Date 10/1/1998
(9) Checker W.L. Willis [signature] 10/1/98 Date 10/1/1998

(10) **Objective:** Verify the diluent volume specified in Table 4.1 is sufficient to flush transfer lines.

Design inputs:
Longest transfer line route - 5627 ft.
Diameter of transfer lines - 3 inches
Volume required to flush lines - 1.5 times pipeline volume
Volume available to flush transfer pipeline -Up to 1 tank volume

Sources:
Longest transfer line route - HNF-2941, Figure A-4.
Diameter of transfer lines - HNF-2941, Table A-5
Volume required to flush lines - HNF-2938, Table 4.1, 7.P4.2
Volume available to flush transfer pipeline - HNF-2938, Table 4.1, 4.P1.2, 4.P1.2, 4.P2.2

Assumptions:

None

Reference:

Calculations:

Volume=Area x Length Area for circle=Pi x R^2; R=Pipe radius, Pi=3.14
Volume = Pi x R^2 x Length Length=5627 ft.
Volume = 3.14 x $(3/2)^2$ (inches^2) x (1 ft/12in)^2 x 5267 ft
Volume = 258.5 ft^3
or
Volume = 258.5 ft^3 x 7.48 Gal/ft
Volume = 1933.1 Gal or ~ 2000 Gal.

Conclusions:

Diluent system is to be capable of delivering up to one tank volume or approximately 1 million gallons. Therefore, the diluent system can sufficiently supply the transfer line flushing requirements.

F.2.1 CALCULATION OF OPERATING TRANSFER RATES

Calculation note

Prepared by W.L. Willis [signature]

Checked by AB Carlson [initials]

Subject: Estimation of operating transfer rates for waste transfers

This calculation will establish a methodology for estimating the transfer rates for waste being transferred from one double shell tank to another or from one double shell tank to the private immobilization facility. The transfer rate will be estimated by plotting the pump head curve versus flow rate given us by the manufacturer of the pump. Superimposed on the pump curve will be the operating head loss versus flow rate curve. The intersection of the two curves gives us an estimate of the flow rate and total head loss through the piping system.

The operating head loss versus flow rate curve is obtained using Bernoulli's Therom (Crane 1982 equation 3.5) which can be stated as follows:

$$h_L = (Z_1 - Z_2) + (144\,[\frac{P_1}{\rho_1} - \frac{P_2}{\rho_2}]) + (\frac{v_1^2 - v_2^2}{2g}) \qquad (1)$$

Where:

- h_L is the total head loss, in feet
- Z is the elevation of the transfer, in feet
- P is the pressure of the system, in pounds per square inch (gauge)
- ρ is the fluid density, pounds per cubic foot
- v is the mean velocity of flow, in feet per second

The total head loss is the sum of the head loss from the elevation change, the pressure loss due to friction and the change in velocity. If we assume that the fluid is incompressible, and the piping has a constant 3" diameter, Then equation 1 can be simplified to:

$$h_L = (\Delta Z) + (144\frac{\Delta P}{\rho}) \qquad (2)$$

The two factors on the right hand side of equation 2 define the total head loss in a piping system. The first term on the right in equation 2 is the elevation rise or drop in the transfer line which is listed in Table A-5 for each route. The second term on the right in equation 2 is the frictional head loss. The frictional head loss can be calculated using Darcy's formula which can be expressed as the following equation (Crane 1982 equations 1-4 and 3-5.):

$$h_{L_{friction}} = f \times \frac{L}{D} \times \frac{v^2}{2g} = 144 \frac{\Delta P}{\rho} \qquad (3)$$

Where:

$h_{L\,friction}$ = frictional head loss, in feet
L = length of pipeline, in feet
D = internal diameter of transfer pipe, in feet
g = acceleration due to gravity, in feet per sqare second

The inside diameter of the pipeline is known (throughout this evaluation 3 in pipe is assumed. The inside diameter of three inch pipe is 3.068 inches), the acceleration due to gravity is assumed to be constant (32.2 feet per square second). We therefore are left with the the friction factor, pipe length, and velocity terms. The friction factor f can be determined graphically using a Moody diagram. Alternatively, a method has been developed by M. Shacham (Olujic 1981) wherein f can be calculated using the following formula:

$$f = \left(-2\ Log\left[\frac{\epsilon/D}{3.7} - \frac{5.02}{Re_D}\log\left(\frac{\epsilon/D}{3.7} + \frac{14.5}{Re_D}\right)\right]\right)^{-2} \qquad (4)$$

Where:

ϵ = surface roughness factor (0.0018 in. for commercial steel (DeNevers 1977))
Re_D = Reynolds Number for flow in pipe

Reynolds Number for flow through pipe is given by:

$$Re_D = \frac{Dv\rho}{\mu} \qquad (5)$$

Where:

μ = fluid viscosity

With f determined by calculation, the next parameter is line length. The line length for each of the transfer lines was estimated from the best available drawings and is listed in table A-5. The bulk velocity of the fluid is related to the flow rate and the cross sectional area of the pipe as follows:

$$v = \frac{\textit{flow rate}}{\textit{cross-sectional area}} \qquad (6)$$

A spreadsheet was developed (see table 1) which calculated first the Reynolds Number using equation 5, then the friction factor using equation 4, and finally the head loss using equations 2 and 3 for a series of volumetric flow rates and viscosities. Curves were generated for flow rates from 40 to 250 gallons per minute, and for viscosities of between 5 and 30 centipoise.

With the pressure drop versus flow-rate curve developed, the next step is to compare the pressure-drop versus flow rate curve to the pump curve to determine where the two curves interssect. In order to do this the computer program Tablecurve-2d ® was used to fit the pump curve in the form of a cubic equation. The pump curve and pressure drop versus flow rate curve were plotted in an Excel ® Spreadsheet. Table 1 is the result of the spreadsheet. Figure 1 is a plot of the operating curves for a transfer from Tank 241-AN-101 to Tank 241-AP-103 for a density of 1.41 g/ml, and viscosities of 5, 10, 15, and 20 centipoise and the pump curve for the pump located in tank 241-AN-101. The transfers to and from 241-An and 241-AZ were done using the same spreadsheet with the transfer length and hydraulic change adjusted to the appropriate levels.

For an equivalent length = 2875
for a hydraulic change = 11.4583

for density of 1.41

Flow Rate gal/min	Reynolds numbers for 3" Pipe – Viscosity (cp) 5	10	15	20	friction factors – Viscosity (cp) 5	10	15	20	total head loss (ft) – Viscosity (cp) 5	10	15
60	17452	8726	5817	4363	0.0279602	0.0328007	0.0363347	0.0392186	44.60	50.34	54.53
70	20361	10180	6787	5090	0.0270603	0.0316024	0.0349224	0.0376315	55.12	62.45	67.80
80	23270	11635	7757	5817	0.0263273	0.0306234	0.0337682	0.0363347	66.94	75.99	82.62
90	26178	13089	8726	6545	0.0257151	0.0298033	0.0328007	0.0352477	80.04	90.95	98.94
100	29087	14544	9696	7272	0.0251938	0.0291026	0.0319736	0.0343183	94.42	107.29	116.74
110	31996	15998	10665	7999	0.024743	0.0284945	0.0312553	0.033511	110.04	124.99	135.99
120	34905	17452	11635	8726	0.0243482	0.0279602	0.0306234	0.0328007	126.91	144.03	156.66
130	37813	18907	12604	9453	0.0239988	0.0274856	0.0300618	0.0321691	145.01	164.41	178.75
140	40722	20361	13574	10180	0.0236868	0.0270603	0.0295579	0.0316024	164.33	186.10	202.22
150	43631	21815	14544	10908	0.0234061	0.0266763	0.0291026	0.0310899	184.87	209.10	227.07
160	46539	23270	15513	11635	0.0231519	0.0263273	0.0286882	0.0306234	206.62	233.39	253.29
170	49448	24724	16483	12362	0.0229203	0.0260083	0.028309	0.0301963	229.57	258.96	280.85
180	52357	26178	17452	13089	0.0227082	0.0257151	0.0279602	0.0298033	253.72	285.80	309.76
190	55265	27633	18422	13816	0.0225132	0.0254446	0.0276378	0.0294399	279.07	313.92	339.99
200	58174	29087	19391	14544	0.0223331	0.0251938	0.0273388	0.0291026	305.61	343.29	371.54

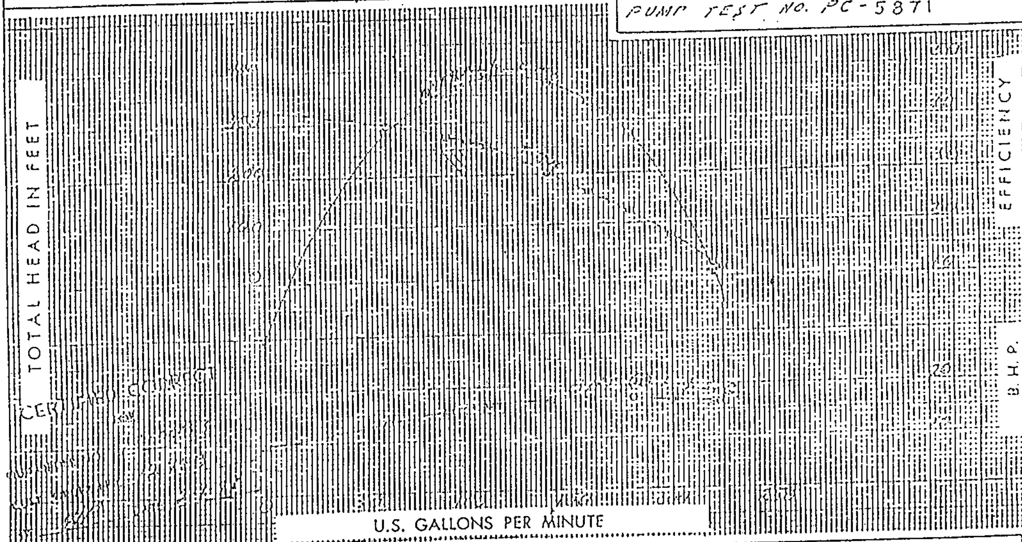
F-55

	Peabody Pump	
ft	cubic Factors	
ft	a	324.24559
	b	0.076078517
	c	-0.007120114
	d	2.80165E-06
	for an equation	
	of the form	
20	Y=a+bx+cx^2+dx^3	

	Pump Head (ft)
57.95	303.78305
72.18	295.64349
88.03	286.19759
105.47	275.46214
124.46	263.45395
144.98	250.18985
166.99	235.68663
190.47	219.9611
215.42	203.03008
241.80	184.91038
269.60	165.61381
298.81	145.17217
329.42	123.58727
361.41	100.88094
394.77	77.069963

Performance shown is the result of a test conducted in accordance with latest Hydraulic Institute Standards. Other standards applicable when mutually agreed upon.

ATLANTIC RICHFIELD HANFORD CORP.
RICHLAND WASHINGTON
P.O. WYN-BOP-26455
1 20HP DEEPWELL PUMP
PUMP TEST NO. PC-5871



PICATTI BROS INC.
PO BOX 2367
YAKIMA, WASHINGTON

Peabody Floway

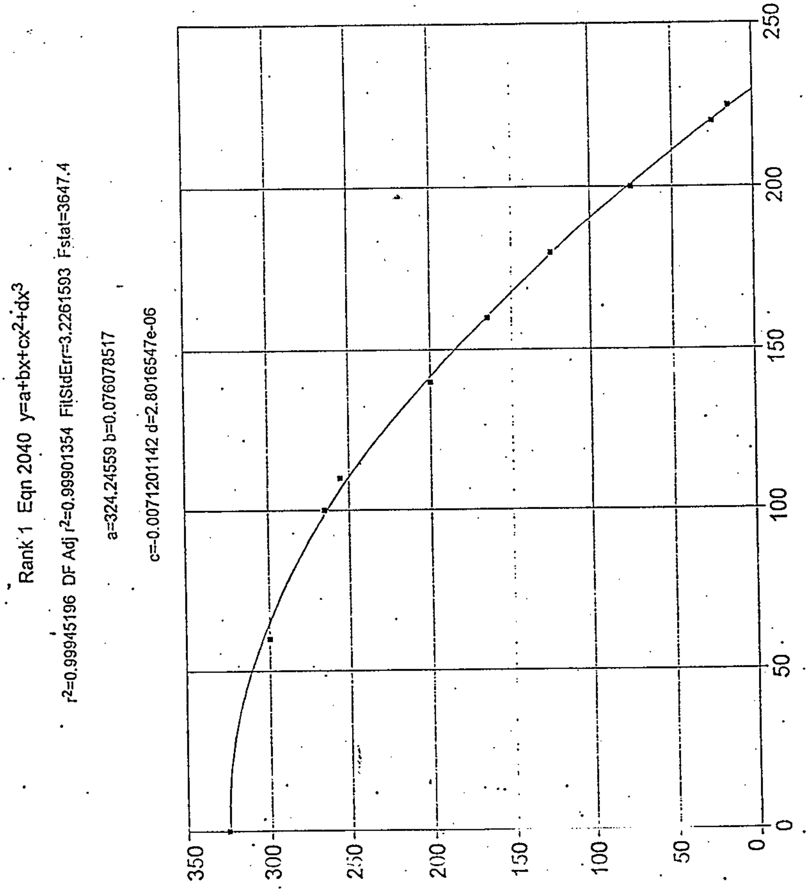
TYPE 6 JOLL
NO. OF STAGES 5
R.P.M. 3520
PUMP SERIAL NO. 77-3683-1

DWG. NO. 77-3683-1

DWN. BY JNG DATE 7-2-78

Form FPI-214

J03P-TX1


Rank 1 Eqn 2040 y=a+bx+cx^2+dx^3
r^2=0.99945196 DF Adj r^2=0.99901354 FitStdErr=3.2261593 Fstat=3647.4
a=324.24559 b=0.076078517
c=-0.0071201142 d=2.8016547e-06
0
50
100
150
200
250
300
350
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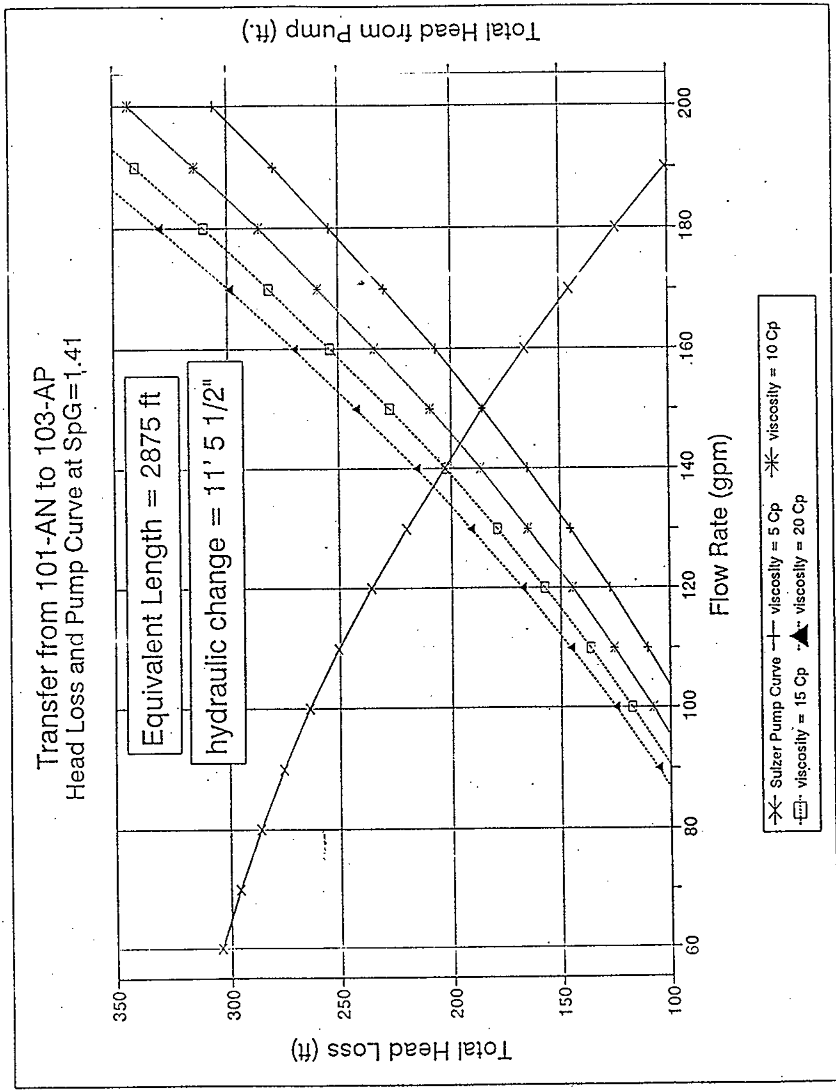
50
100
150
200
250


Transfer from 101-AN to 103-AP
Head Loss and Pump Curve at SpG=1.41
Equivalent Length = 2875 ft
hydraulic change = 11' 5 1/2"
Total Head from Pump (ft.)
Total Head Loss (ft)
Flow Rate (gpm)
350
300
250
200
150
100
60
80
100
120
140
160
180
200
Sulzer Pump Curve
viscosity = 5 Cp
viscosity = 10 Cp
viscosity = 15 Cp
viscosity = 20 Cp

F.2.2 CALCULATION OF TRANSFER LINE WATER HAMMER

FLUOR DANIEL NORTHWEST INC.	CALCULATION IDENTIFICATION AND INDEX	Page 1 of 1 Date: 7/27/98

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Piping WO/Job No. 65100501 051X126 Calculation No. 051X126-P-03

Project No. & Name Pressure surges due to waste transfers between 241-AN to 241-AP, 241-AZ to PC, & 241-AY to AZ

Calculation Item N/A

These calculations apply to:

Dwg. No. N/A Rev. No.

Dwg. No. N/A Rev. No.

Other (Study, CDR) N/A Rev. No.

The status of these calculations is:

N/A

Incorporated In Final Drawings N/A [ ] Yes [ ] No

This calculation verified by independent "check" calculations [ ] Yes [✓] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date	Rev. 3 Signature/Date
Originator	[signature] 8/3/98			
Checked by	[signature] 8/3/98			
Approved by	[signature] 8/3/98			
Checked Against Approved Vendor Data	N/A			

INDEX

Design Analysis Page No.	Description
1	Purpose, Method, Assumptions, Design Input, and References
2	Calculation
8	Conclusions
Attachments	

FDNW CALC COVER

FLUOR DANIEL NORTHWEST INC.	CALCULATION IDENTIFICATION AND INDEX	Page 1 of 1 Date: 7/27/98

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Piping WO/Job No. 65100501 051X126 Calculation No. 051X126-P-03

Project No. & Name Pressure surges due to waste transfers between 241-AN to 241-AP, 241-AZ to PC, & 241-AY to AZ

Calculation Item N/A

These calculations apply to:

Dwg. No. N/A Rev. No.

Dwg. No. N/A Rev. No.

Other (Study, COR) N/A Rev. No.

The status of these calculations is:

N/A

Incorporated In Final Drawings N/A [ ] Yes [ ] No

This calculation verified by independent "check" calculations [ ] Yes [✓] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date	Rev. 3 Signature/Date
Originator	RT Hebbe 8/3/98			
Checked by	[signature] 8/3/98			
Approved by	RT Hebbe 8/3/98			
Checked Against Approved Vendor Data	N/A			

INDEX

Design Analysis Page No.	Description
1	Purpose, Method, Assumptions, Design Input, and References
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FORM CALC COVER

Fluor Daniel Northwest		Calc. No. 051X126-P-03
DESIGN ANALYSIS		Revision 0
		Page No. 1 of 9
Client NHC	WO/Job No. 65100501 051X126	
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.	Date 7/27/98	By R.T.Hallum
	Checked 8/13/98	By [signature]
Location Richland, WA	Revised / /	By

PURPOSE

The purpose of this calculation is to determine the pressure transient, or water hammer, from the instantaneous and a slow closing valve in a waste transfer piping system. The waste transfer systems analyzed are the transfers from 241-AN-105 to 241-AP-102, 241-AZ-101 to the privatization contractor (PC), and 241-AY-102 to 241-AZ-101. The transfers analyzed are the conceptual waste transfer line routings discussed in HNF-2500 (reference 5).

METHOD

Hand calculations using formulas and data drawn from sources listed under references.

ASSUMPTIONS

1. This calculation assumes the closure of the valve at the end of the waste transfer line is instantaneously closed.
2. Waste characteristics and waste transfer requirements are based on information provided by NHC (see Design Input).
3. The distance from the PHMC/PC interface to the closing valve in the PC facility is 2,600 feet (see attachment).
4. The location of the PC's facility is within Parcel A and the routing of the waste line is along existing roads (see attachment).

DESIGN INPUT

1. Electronic memo from Alan B Carlson to Randall Hallum, dated 7/13/98 and attachment.

REFERENCES

1. Analysis and Control of Unsteady Flow in Pipelines, Gary Z. Watters, Second Edition.
2. Process Piping Code, ASME B31.3b-1997
3. W-314-C1, Construction Specification, Tank Farm Restoration and Safe Operations, AN Valve Pit Upgrades
4. Flow of Fluids through Valves, Fittings, and Pipe; Crane Technical Paper No. 410
5. HNF-2500, W-314 Waste Transfer Alternative Piping System Description, Rev. 0.
6. Standard Handbook of Engineering Calculations, Tyler G. Hicks, P.E., Editor.
7. H-2-71986, Piping Plan 241-AN Tank Farm
8. H-2-71994, Piping Plan Tank 104
9. H-14-102088, Piping Tanks AP-102/104 Area Plan (Project W-211, drawing is not released for construction)
10. Piping Handbook, sixth edition, Mohinder L. Nayyar, Editor.

Fluor Daniel Northwest		Calc. No. 051X126-P-03
DESIGN ANALYSIS		Revision 0
		Page No. 2 of 9
Client NHC	WO/Job No. 65100501 051X126	
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.	Date 7/27/98	By R.T.Hallum
	Checked 8/3/98	By [signature]
Location Richland, WA	Revised / /	By

CALCULATION

Pipe Data:

3 inch schedule 40S, ASTM A 312 Grade TP 304L, seamless (reference 3)

$D = 3.500"$	pipe diameter	(reference 4)
$e = .216"$	pipe wall diameter	(reference 4)
$E_s = 27.6 \times 10^6$	modulus of elasticity for austenitic stainless steel at 200°F	(reference 2)

Waste Transfer Routing Data (reference 5) and Waste Property Data:

	AN to AP[1]	AZ to PC[2]	AY to AZ[3]
Routing Length (ft)	2,800	5,100	700
Waste Density (g/cc)	1.41	1.25	1.25
Waste Velocity (ft/sec)	9	9	9
Temperature (°F)	200	200	200

[1] 241-AN-05A pit via 3"SN-265-M25 to 241-AN-A valve pit (H-2-71986). 241-AN-A valve pit via 3"SN-264-M25 to 241-AN-04A pit (H-2-71994). 241-AN-04A pit via 3"SN-636 to 241-AP-04D pit (HNF-2500). 241-AP-04D pit to 241-AP-02D pit (H-14-102088). AP-102-02D pit to AP-102-02A pit.

[2] 241-AZ-01A pit to new AZ valve pit. New AZ valve pit to PC (privatization contractor) interface (HNF-2500). PC interface to PC facility (see attachment).

[3] 241-AY-02A pit to new AZ valve pit. New AZ valve pit to 241-AZ-01A pit.

The wave velocity created from an instantaneous closing valve will be determined from the methods given in reference 1.

$$a := \frac{\left[\dfrac{K}{SG \cdot \left(\dfrac{\rho}{g}\right)}\right]^{\frac{1}{2}}}{\left[1 + \left(\dfrac{K}{E} \cdot \dfrac{D}{e} \cdot C\right)\right]^{\frac{1}{2}}}$$

(reference 1, eq 5.18)

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Fluor Daniel Northwest

DESIGN ANALYSIS

Calc. No. 051X126-P-03
Revision 0
Page No. 3 of 9

Client NHC
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.
Location Richland, WA

WO/Job No. 65100501 051X125
Date 7/27/98 By R.T.Hallum
Checked 8/13/98 By [signature]
Revised / / By

Where:

a = wave velocity, ft/sec
g = gravitational constant, 32.2 ft/sec²
SG = specific gravity
ρ = weight density of fluid, lb/ft³
K = bulk modulus of compressibility of liquid, psi (reference 1, pg 91)
= 300, 000 psi (reference 1, pg 91)
D = pipe inside diameter, in
= 3.068" (reference 4)
e = pipe wall thickness, in
= .216" (reference 4)
C = restraint condition (used *case b* for pipes anchored against longitudinal strain) (reference 1, pg 94)

$$C := \left[\frac{1}{\left(1+\frac{e}{D}\right)}\right]\cdot\left[\left(1-\mu^2\right)+2\cdot\frac{e}{D}\cdot(1+\mu)\cdot\left(1+\frac{e}{D}\right)\right]$$

$C = 1.033$

Where μ = 0.3 (Poison's Ratio for steel) (reference 1, pg 91)

241-AN to 241-AP Waste Transfers

Determine the wave velocity for waste being transferred from 241-AN to 241-AP (see table on routing and waste characteristics above):

Convert density of waste being transferred from AN to AP from metric to English units (grams/cubic centimeter to slug/cubic foot):

$\text{Density} := 0.00141\cdot\frac{kg}{cm^3}$ Density of waste being transferred.

$\text{Vol\_conv} := 3.531\cdot10^{-5}\cdot\frac{ft^3}{cm^3}$ Conversion of cubic centimeters to cubic feet.

$\text{Mass\_conv} := 0.0685\cdot\frac{slu}{kg}$ Conversion of kilograms to slug.

BD-6002-112 (2/97) CD'd95 CALCSHT.XY6

Fluor Daniel Northwest

DESIGN ANALYSIS

Calc. No. 051X126-P-03
Revision 0
Page No. 4 of 9

Client NHC

Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.

Location Richland, WA

WO/Job No. 65100501 051X126

Date 7/27/98 By R.T.Hallum

Checked / / By ___________

Revised / / By ___________

$$Density_{AN} := \frac{DensityMass\_con}{Vol\_conv}$$

$$Density_{AN} = 2.735 \cdot \frac{slug}{ft^3}$$

$$a := \frac{\left[\frac{(3 \cdot 10^5) \cdot 144}{2.735}\right]^{\frac{1}{2}}}{\left[1 + \left[\frac{(3 \cdot 10^5) \cdot 144}{(27.6 \cdot 10^6) \cdot 144} \cdot \frac{3.068}{.216} \cdot 1.033\right]\right]^{\frac{1}{2}}}$$

$a = 3.691 \cdot 10^3$ ft/sec (wave velocity)

Determine the increase in pressure from instantaneous valve closure for waste transfers from AN to AP:

$$\Delta H := \left(\frac{a}{g}\right) \cdot v$$

Where ΔH is the increase in pressure head from the valve closure and v is the change in velocity of the fluid (reference 1, equation 5.4).

$$\Delta H := \left(\frac{3691}{32.2}\right) \cdot 9$$

Pressure surge deviation from normal in feet of liquid.

$\Delta H = 1.032 \cdot 10^3$ ft of liquid

Or p_s = 1032 ft of liquid · 1.41 · .433 = 630 psig increase in pressure due to water hammer.

Determine the increase in pressure from a slow closing valve for waste transfers from AN to AP. Slow closing will be defined as a closing time equal to one wave cycle (the time a pressure wave travels to the other end of the pipeline and returns to the closing valve).

BD-6400-142 (07/97) CETAH CALCFLN74

Fluor Daniel Northwest DESIGN ANALYSIS		Calc. No. 051X126-P-03 Revision 0 Page No. 5 of 9
Client NHC	WO/Job No. 65100501 051X126	
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.	Date 7/27/98	By R.T.Hallum
	Checked / /	By
Location Richland, WA	Revised / /	By

Find the wave cycle for the transfer line from 241-AN to 241-AP:

$$\tau := 2 \cdot \frac{L}{a}$$ (reference 10)

Where:
- τ = Wave cycle, seconds
- L = Pipeline length, ft (2,800 feet for AN to AP transfers)
- a = Pressure surge wave velocity, ft/sec (see above calculations)

τ = 1.5 seconds

Pressure surge for various time periods based on the wave cycle:

$$p_i := \frac{2 \cdot p_s \cdot L}{a \cdot i \cdot \tau}$$ (reference 6)

Where:
- p_i = Pressure surge from slow closing valve, psi
- L = Pipeline length, ft
- a = Pressure surge wave velocity, ft/sec
- i = Number of wave cycles
- τ = Wave cycle, seconds
- p_s = Pressure surge calculated above in psi (from instantaneous closure)

Results:

i	p_i
1	630
2	315
3	210
4	157
5	126
6	105
7	90
8	79
9	70
10	63

BD-6400-142 (7/97) CEF109 CALC97.N76

Fluor Daniel Northwest DESIGN ANALYSIS		Calc. No. 051X126-P-03 Revision 0 Page No. 6 of 9
Client NHC	WO/Job No. 65100501 051X126	
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.	Date 7/27/98	By R.T.Hallum
	Checked / /	By
Location Richland, WA	Revised / /	By

<u>241-AZ to the PC Waste Transfers</u>

Determine the wave velocity for waste being transferred from 241-AZ to the PC (see table on routing and waste characteristics above):

$$a := \frac{\left[\frac{(3\cdot 10^5)\cdot 144}{2.425}\right]^{\frac{1}{2}}}{\left[1+\left[\frac{(3\cdot 10^5)\cdot 144}{(27.6\cdot 10^6)\cdot 144}\cdot\frac{3.068}{.216}\cdot 1.033\right]\right]^{\frac{1}{2}}}$$

$a = 3.92\cdot 10^3$ ft/sec

Determine the increase in pressure from instantaneous valve closure for waste transfers from AZ to PC:

$$\Delta H := \left(\frac{3920}{32.2}\right)\cdot 9$$

$\Delta H = 1.096\cdot 10^3$ ft of liquid

Or p_r = 1096 ft of liquid · 1.25 · .433 = 593.2 psig increase in pressure due to water hammer.

Determine the increase in pressure from a slow closing valve for waste transfers from AZ to the PC. Slow closing will be defined as a closing time equal to one wave cycle (the time a pressure wave travels to the other end of the pipeline and returns to the closing valve):

Find the wave cycle for the transfer line from 241-AZ to the privatization contractor's facility:

$$\tau := 2\cdot\frac{L}{a}$$

$\tau = 2.602$ seconds

BD-6400-(12/97) CET-04 CALC01.WPT

Fluor Daniel Northwest DESIGN ANALYSIS		Calc. No. 051X126-P-03 Revision 0 Page No. 7 of 9
Client NHC	WO/Job No. 65100501 051X126	
Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.	Date 7/27/98	By R.T.Hallum
	Checked / /	By
Location Richland, WA	Revised / /	By

Pressure surge for various time periods based on the wave cycle:

$$p_i := \frac{2 \cdot p_s \cdot L}{a \cdot i \cdot \tau}$$

i	p_i
1	593
2	297
3	198
4	148
5	119
6	99
7	85
8	74
9	66
10	59

Where i = wave cycles and p_i = pressure increase, in psi, based on the number of wave cycles.

<u>241-AY to 241-AZ Waste Transfers</u>

The calculations to determine surge pressure wave velocity and increase in pressure from the instantaneous valve closure are identical to the calculations performed for 241-AZ to the PC (see above). The difference between 241-AY to 241-AZ and 241-AZ to the PC waste transfers are the length of the transfer routes. Below is the calculations which are dependent on the length of the transfer routes which are the wave cycle time and the pressure surges for slow closing valves.

Find the wave cycle for the transfer line from 241-AZ to the privatization contractor's facility:

$$\tau := 2 \cdot \frac{L}{a}$$

$\tau = 0.357$ seconds

Pressure surge for various time periods based on the wave cycle:

$$p_i := \frac{2 \cdot p_s \cdot L}{a \cdot i \cdot \tau}$$

BD-6400-142 (9/97) GEF109 CALCSHT.876

Calc. No. 051X126-P-03
Revision 0
Page No. 8 of 8

Fluor Daniel Northwest

DESIGN ANALYSIS

WO/Job No. 65100501 051X126

Client NHC

Subject Pressure surges due to waste transfers between from 241-AN to 241-AZ, 241-AZ to PC, and 241-AY to 241-AZ.

Location Richland, WA

Date 7/27/98 By R.T.Hallum

Checked 8/13/98 By [signature]

Revised / / By

i	p_i
1	593
2	297
3	198
4	148
5	119
6	99
7	85
8	74
9	66
10	59

Where i = wave cycles and p_i = pressure increase, in psi, based on the number of wave cycles.

Conclusions:

See below:

Routing	SG	Fluid Velocity (ft/sec)	Water Hammer Pressure Wave Velocity (ft/sec)	Increase in Pressure from Instantaneous Valve Closure (psig)	Increase in Pressure from a Slow Closing (2·τ) Valve (psig)	2·τ (sec)
AN to AP	1.41	9.0	3691	332.0	315	3.0
AZ to PC	1.25	9.0	3920	404.2	297	5.2
AY to AZ	1.25	9.0	3920	355.3	297	0.71

BD-6400-142 (12/97) CCF-09 CALC97.W96

Attachment
051X126-P.03
Ref Design Input
Pg 1

Attached file: fdnwscop. 7/13/98

Author: Alan B Carlson at ~HANFORD03B
Date: 7/13/98 10:14 AM
Priority: Normal
TO: Randall T Hallum at FDNW-01
CC: Mark W Manderbach at ~HANFORD04D
CC: Ivan G Papp at ~HANFORD15C
CC: William L Willis at ~HANFORD09B
CC: Brian B Peters at ~HANFORD21F
CC: Tony R Benegas at ~HANFORD05A
CC: Alan B Carlson
Subject: Re: Additional Scope Related to AN and AZ Assessments

Message Contents

Randall,
I apologize for not attaching the file the first time.
Alan

Reply Separator

Subject: Additional Scope Related to AN and AZ Assessments
Author: Alan B Carlson at ~HANFORD03B
Date: 7/13/98 9:07 AM

Randall,

Attached is an electronic version of the work scope which you, Bill Willis, and I discussed on the afternoon of Thursday 7/9. I have made an editorial change under the Heat Up/Heat Loss Through Routes scope to state that temperature drop rather than heat loss calculations have been completed... This refers to the set of calculations provided via Bill Willis at the meeting. Also, under the water hammer section I discussed the time period to assume for the slow closing valve based on the velocity of wave propagation.

Based on our conversation at the meeting Thursday I anticipate seeing a work plan today showing the completion of all the work scope activities by 7/31.

Thanks,
Alan Carlson

BEST AVAILABLE COPY

Attachment
051X126-R-03
LAF Design Input
1 of 2
July 9, 1998

Additional Scope of Work - FDNW Support of AN and AZ Farm Assessments

Heat Up/Heat Loss Through Routes

Temperature drop calculations have been completed for waste transfers (see attached). Verify the previous calculations bound the cases we are examining and provide a writeup of the findings.

Calculate the time required to heat up the transfer pipe to steady state conditions and specify the internal pipe temperature at the steady state condition. The conditions to consider shall be waste transferred at 40oC (104oF) through a 3" pipe within a 6" pipe. The 3" pipe starts at ambient underground temperature of 50oF. The waste flowing through the pipe is at 6 ft/s (turbulent well-mixed flow). Assume a constant temperature boundary of 50oF at 5 feet out radially from the center of the pipe.

Water Hammer Calculations

Prepare three separate water hammer calculations for the waste feed delivery transfers (1) from AN to AP farm, (2) from AZ to the high level waste vendor and (3) from AY to AZ farm. The calculations shall consider two different cases for the transfers: a fast closing valve and a slow closing valve. For the slow closing valve case assume that the time to close the valve is two times the pipe time period. The pipe time period is equal to two times the length of the pipe divided by the velocity of wave propagation. The valve shall be assumed to be located at the end of the transfer line.

For AN transfer to AP water hammer calculations the calculation will be based on the transfer from AN-105 to AP-102. The waste for AN transfers shall assume a density of 1.41 g/cc. Fluid flow rate of 140 gpm and 210 gpm (nominally 6 ft/s and 9 ft/s respectively). Transfers are through 3" SCH 40 carbon steel pipe.

For AZ transfer water hammer calculations the calculation will be based on the transfer from AZ-101 to high level waste vendor and AY-102 to AZ-101. The waste for AZ transfers shall assume a density of 1.25 g/cc. Fluid flow rate of 140 gpm and 210 gpm (nominally 6 ft/s and 9 ft/2 respectively). Transfers are through 3" SCH 40 carbon steel pipe.

Evaluation of Line Draining (Hydraulic Diagrams)

Review the existing tank pits and valve pits in AN and AZ tank farms (See H-2-71985 for AN Farm) and planned routes for waste transfers including newly proposed transfer lines and transfer pits (See Drawing D153A from HNF-2500, Rev. 0) identified under Project W-314 in order to prepare hydraulic diagrams.

A hydraulic diagram shall be prepared for AN farm showing the elevations associated with waste transfers from AN-102, AN-103, AN-104, AN-105, AN-107 to both

Attachment
051X126-P.03
3

AP-102 and AP-104. The diagram should show elevations of nozzles in each transfer route and specify the location of the high point of each transfer route.

A hydraulic diagram shall be prepared for AZ farm showing the elevations associated with waste transfers from AZ-101 and AZ-102 to the private vendor. Additionally, the hydraulic diagram shall show the elevations associated with transfer route from AY-102 to AZ-101 and from AY-102 to AZ-102. The diagram should show elevations of nozzles in each transfer route and specify the location of the high point of each transfer route.

An example hydraulic diagram is provided in drawing D153A from HNF-2500, Rev. 0. Darren Dixon will provide CAD support for drawing of the diagrams.

Evaluation of Ventilation Condensation Routing

Review the existing ventilation condensation routings for AN and AZ tank farms. Identify the routes and receiver tanks for collected condensate in both AN and AZ tank farms.

A drawing shall be prepared for AN farm showing the condensation routing associated with each tank ventilation system (and any other sources of condensate) in AN Farm. The drawing shall identify whether the condensate lines are single or encased lines. A written description of the finding shall be completed.

A drawing shall be prepared for AZ farm (and AY farm connections as well) showing the condensation routing associated with each tank ventilation system (and any other sources of condensate) in AZ Farm. The drawing shall identify whether the condensate lines are single or encased lines. A written description of the finding shall be completed.

Identify Transfer Routes Which Need to be Plugged or Abandoned

Identify nozzles which will not be needed during phase 1 privatization for any transfers. These nozzles should be plugged to reduce the risk of misrouting during transfer. HNF-2854, Rev. 0 evaluates nozzles for blanking.

Corrosion Requirements and Materials of Construction Evaluation

There has been an ongoing discussion regarding the need for using inhibited water (defined as raw water that contains at least 0.01 M NaOH and 0.011 M NaNO2) to flush the pipelines following waste transfers between tanks. The rational for the use of inhibited water is the resulting reduction in corrosion of the transfer piping relative to the use of plain raw water for flushing. The volume of flush water will range from 1-2 pipeline volumes.

The issue to be resolved, is whether or not the use of inhibited water provides a meaningful corrosion reduction. If inhibited flush water is determined to be appropriate, develop specific requirements for both carbon steel pipelines (currently existing) and for the stainless steel pipelines that Project W-314 is

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planning.

Expected Product: A defined requirement relative to the use of inhibited water for flushing of carbon steel and stainless steel transfer lines with a defensible technical justification.

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Second Edition

ANALYSIS AND CONTROL OF UNSTEADY FLOW IN PIPELINES

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Case (a) % change in water volume $= 100\frac{\rho a^2}{K} = 100\frac{1.94 \times 3413^2}{3 \times 10^5 \times 144}$

$= 52\%$

The remainder is in pipe stretching $= 48\%$

Case (b) % change in water volume $= 100\frac{1.94 \times 3448^2}{3 \times 10^5 \times 144} = 53\%$

The remainder is in wall stretching $= 47\%$

Case (c) % change in water volume $= 100\frac{1.94 \times 3371^2}{3 \times 10^5 \times 144} = 51\%$

The remainder is in wall stretching $= 49\%$

5.3 WAVE SPEEDS IN OTHER TYPES OF CONDUITS

The simplest case of thin-walled pipes has been used previously to derive equations for wave speed. It is obvious that many hydraulic conduits are constructed of thick-walled pipe and often using two or more materials (reinforced concrete). Also tunnels may be carved in rock, lined with steel, and back-filled with concrete. It is necessary to be able to calculate wave speeds in all these cases.

A concise summary of the calculation of the wave speeds for these cases is given by Halliwell [25]. The most obvious extension of the previous example of thin-walled pipes is to thick-walled pipes. In a thick-walled pipe, the wall thickness is so great that stress varies noticeably between the inner and outer surfaces and this affects the expression for wave speed. An analysis reveals that we may continue to use the same basic form for the wave speed equation, but we must find a different value for the C in Equation (5.18).

Thick-Walled Pipes

Summarizing the results for thick-walled pipes for the same restraint conditions as before with D as the inside diameter,

Case (a)—For pipes free to stress and strain both laterally and longitudinally (anchored at only one point)

$$C = \frac{1}{1 + \frac{e}{D}}\left[\left(\frac{5}{4} - \mu\right) + 2\frac{e}{D}(1 + \mu)\left(1 + \frac{e}{D}\right)\right] \qquad (5.20a)$$

A limiting process shows that as $e/D \to 0$, this equation degenerates to Equation (5.19a).

Case (b)—For pipes anchored against longitudinal strain

$$C = \frac{1}{1 + \frac{e}{D}}\left[(1 - \mu^2) + 2\frac{e}{D}(1 + \mu)\left(1 + \frac{e}{D}\right)\right] \qquad (5.20b)$$

Case (c)—For pipes with *functioning* expansion joints throughout their length

$$C = \frac{1}{1 + \frac{e}{D}}\left[1 + 2\frac{e}{D}(1 + \mu)\left(1 + \frac{e}{D}\right)\right] \qquad (5.20c)$$

As in case (a), both cases (b) and (c) degenerate to the thin-walled pipe values when $e/D \to 0$.

The question arises as to when the more complex thick-walled formulas should be applied. For deciding, it is helpful to examine the plot of these equations in Figure 5.1. To assist in making this decision, consider the uncertainties of pipe restraint and its effect on wave speed. Figure 5.1 shows that uncertainty with respect to the type of restraint occurring can cause differences of about 10 percent between C-values at the two extremes of restraint. If we accept a similar error in deciding whether to use thin-walled or thick-walled formulas, then a D/e value of 20 is an appropriate dividing line. If, however, we decide to remove as much uncertainty as possible, then the thick-walled formulas should always be used. The additional computation required is negligible. In a practical sense though, because of the relative size of terms in the denominator of Equation (5.18), using thick-walled formulas beyond D/e values of 40 generally makes no significant improvement in the value of the wave speed except in cases where softer pipes such as PVC are used. It should also be noted that using the thin-walled formulas leads to higher (more conservative) wave speeds. To see the effect, consider the following example.

Example 5.2. A steel pipe 10 in. in diameter is used to convey water between two reservoirs. The inside diameter of the pipe is 9.522 in. and the wall thickness is 0.239 in.

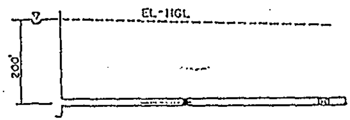
Compute the C-values and wave speeds using both thin- and thick-walled formulas and compare results.

	Wave Speed (fps)		
Restraint	*Thin-Walled*	*Thick-Walled*	*Error* ($D/e = 40$)
Case (a)	4023	3999	0.6%
Case (b)	4047	4021	0.6%
Case (c)	3994	3971	0.6%

presence of any free air in the system can be considered an unforeseen, but fortuitous, occurrence, at least in the sense that it reduces K.

In the limit the pipe can become completely rigid without causing the wave speed to become infinite. This limiting value is obtained by passing E to ∞ in Equation 5.18. With the nominal value of K = 300,000 psi, the resulting wave speed is approximately 4720 fps. This number has no practical value in design because it is far too high to serve as even an approximate wave speed for preliminary design. With even a limited amount of experience, the designer can make far better estimates for wave speed in the pipe he or she is working with.

Example 5.1. As an illustration of the elastic deformations and pressure head changes caused by a water hammer situation and the effect of restraint on wave speed, the following problem is analyzed



Flow in the 24-in. pipeline above occurs at a velocity of 6 fps. The pipeline is fabricated of steel and has a wall thickness of 0.25 in.

a. Calculate the wave speed for all three cases of restraint.

$$\text{Case (a)} \quad a = \frac{4720}{\sqrt{1 + \frac{3 \times 10^5}{3 \times 10^7}\frac{24}{.25}(5/4 - 0.30)}} = 3413 \text{ fps}$$

$$\text{Case (b)} \quad a = \frac{4720}{\sqrt{1 + 0.96(1 - 0.30^2)}} = 3448 \text{ fps}$$

$$\text{Case (c)} \quad a = \frac{4720}{\sqrt{1 + 0.96(1.0)}} = 3371 \text{ fps}$$

In a practical sense, the differences are negligible.

b. Find the head increase resulting from sudden valve closure for all three cases of restraint.

$$\text{Case (a)} \quad \Delta H = \frac{3413}{32.2} \times 6 = 636 \text{ ft}$$

$$\text{Case (b)} \quad \Delta H = \frac{3448}{32.2} \times 6 = 642 \text{ ft}$$

$$\text{Case (c)} \quad \Delta H = \frac{3371}{32.2} \times 6 = 628 \text{ ft}$$

The variation in head increase among the three cases is about 2 percent.

c. Compute the axial and circumferential pipe wall stresses before and after valve closure for all three cases of restraint.

Case (a) Before $\sigma_2 = \frac{200 \times 62.4 \times 24}{144 \times 2 \times .25} = 4160$ psi, $\sigma_1 = 1/2\sigma_2 = 2080$ psi

$\Delta\sigma_2 = \frac{636 \times 62.4 \times 24}{144 \times 2 \times .25} = 13{,}230$ psi, $\Delta\sigma_1 = 6615$ psi

After $\sigma_2 = \sigma_2 + \Delta\sigma_2 = 17{,}390$ psi, $\sigma_1 = 8695$ psi

Case (b) Before σ_2 = same as above, $\sigma_1 = \mu\sigma_2 = 1250$ psi

$\Delta\sigma_2$ = same as above, $\Delta\sigma_1 = \mu\Delta\sigma_2 = 3970$ psi

After σ_2 = same as above = 17,390 psi, σ_1 = 5220 psi

Case (c) Before σ_2 = same as above, $\sigma_1 = 0$

$\Delta\sigma_2$ = same as above, $\Delta\sigma_1 = 0$

After σ_2 = same as above = 17,390 psi, $\sigma_1 = 0$

d. *Calculate the percent increase in diameter of the pipe caused by sudden valve closure.*

$$100\frac{\delta D}{D} = 100\Delta\epsilon_2 = \frac{100}{E}(\Delta\sigma_2 - \mu\Delta\sigma_1)$$

$$\text{Case (a)} \quad \%\ \text{change} = \frac{100}{30 \times 10^6}(13{,}230 - 0.3 \times 6615) = 0.037\%$$

$$\text{Case (b)} \quad \%\ \text{change} = \frac{100}{30 \times 10^6}(13{,}230 - 0.3 \times 3970) = 0.040\%$$

$$\text{Case (c)} \quad \%\ \text{change} = \frac{100}{30 \times 10^6}(13{,}230 - 0.3 \times 0) = 0.044\%$$

This result substantiates many of our previous assumptions used in neglecting small terms.

e. Calculate the percent of the water entering the pipe during wave passage which can be attributed to pipe stretching and to water compression.

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Now considering conservation of mass, we already have Equation (5.5) expressing the amount of mass which has accumulated in the δL pipe section in δt seconds. We can write a different expression for the mass change in the δL pipe section after wave passage. The mass change in the section is

$$\delta M = (\rho + \delta\rho)(A\delta L + \delta V) - \rho A\delta L$$

Equating this expression with Equation (5.5), expanding, and dropping small terms gives

$$\delta\rho A\delta L + \rho\delta V = A\rho\Delta V\frac{\delta L}{a} \qquad (5.15)$$

To arrange this equation in more useable form, note that for a mass of a given substance, an increase in pressure causes a decrease in volume and an increase in density.

$$\rho V = \text{constant}$$
$$V\delta\rho + \rho\delta V = 0$$
$$\delta\rho = -\frac{\delta V}{V}\rho$$

Substituting Equation (5.6) into this equation gives

$$\delta\rho = \rho\left(\frac{\Delta p}{K}\right)$$

Replacing Δp with $\gamma\Delta H$ in the preceding equation, substituting it and Equation (5.14) into Equation (5.15),

$$\gamma\Delta H\left[\frac{1}{K} + \left(\frac{1-\mu^2}{E}\right)\frac{D}{e}\right] = \frac{\Delta V}{a} \qquad (5.16)$$

Combining this equation with Equation (5.4) gives

$$a^2\rho\left[\frac{1}{K} + \frac{D}{e}\left(\frac{1-\mu^2}{E}\right)\right] = 1$$

or in a more conventional form for wave speed,

$$a = \frac{[K/\rho]^{1/2}}{\left[1 + \frac{K}{E}\frac{D}{e}(1-\mu^2)\right]^{1/2}} \text{ (case b)} \qquad (5.17)$$

It is now possible for us to compute wave speed and pressure increase in simple situations where Equation (5.4) can be used.

Streeter and Wylie [1] have shown that the equation for wave speed can be more conveniently expressed as

$$a = \frac{[K/\rho]^{1/2}}{\left[1 + \frac{K}{E}\frac{D}{e}(C)\right]^{1/2}} \qquad (5.18)$$

where

$$C = 5/4 - \mu \quad \text{for case (a) restraint} \qquad (5.19a)$$

$$C = 1 - \mu^2 \quad \text{for case (b) restraint,} \qquad (5.19b)$$

$$C = 1.0 \quad \text{for case (c) restraint} \qquad (5.19c)$$

Recall that this set of equations applies only to thin-walled pipes where D/e is generally greater than about 40 (see Section 5.3).

To assist in calculating wave speeds in pipes constructed of common materials, the following table of E-values and μ-values is included. The value of K for water can be taken as approximately 300,000 psi. While some references cite values ranging as high as 320,000 psi, the value of 300,000 psi seems to represent an average figure. It should be noted that a small amount of free air suspended as bubbles in the water can drastically reduce the K-value (see Section 5.3). However, evaluating the amount of air, its distribution, its pervasiveness, and the exact effect on K is most difficult. Consequently, in the design situation, the larger conservative value is generally used because it predicts the most severe water hammer pressures. The

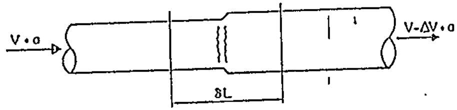
Table 5.1. Moduli of Elasticity and Poisson's Ratio for Common Pipe Materials

Steel	$E = 30 \times 10^6$ psi	$\mu \sim 0.30$
Ductile Cast Iron	$E = 24 \times 10^6$ psi	$\mu \sim 0.28$
Copper	$E = 16 \times 10^6$ psi	$\mu \sim 0.36$
Brass	$E = 15 \times 10^6$ psi	$\mu \sim 0.34$
Aluminum	$E = 10.5 \times 10^6$ psi	$\mu \sim 0.33$
PVC	$E \sim 4 \times 10^5$ psi	$\mu \sim 0.45$
Fiberglass reinforced plastic (FRP)	$E_2 = 4.0 \times 10^6$ psi	$\mu_2 = 0.27–0.30$
	$E_1 = 1.3 \times 10^6$ psi	$\mu_1 = 0.20–0.24$
Asbestos Cement	$E \sim 3.4 \times 10^6$ psi	$\mu \sim 0.30$
Concrete	$E = 57{,}000\sqrt{f_c'}$	$\mu \sim 0.24$ (dynamically)

where $f_c' = 28$-day strength.

is possible to use a translating coordinate system to transform the unsteady flow into a "steady" flow.

If we move our reference system to the left at a speed a we have, for all appearances, a steady flow.



STEADY FLOW

From basic fluid mechanics we have available the one-dimensional impulse-momentum equation [see Equation (2.3)].

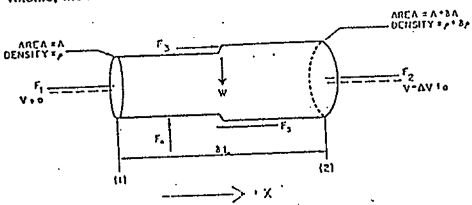
$$\Sigma F_{ext} = (\Sigma Q\rho V)_{out} - (\Sigma Q\rho V)_{in} \tag{5.1}$$

where Q is the discharge, ρ is the liquid density, and ΣF_{ext} is the sum of the external forces acting. The momentum correction factor for nonuniform velocity profiles has been assigned the value of 1.0.

Considering only the component of this vector equation parallel to the pipe and noting that momentum enters and leaves the section of pipe δL long at only one section each, we can write

$$(\Sigma F_{ext})_x = Q\rho\,(V_{out} - V_{in}) \tag{5.2}$$

To apply the impulse-momentum equation we must specify a control volume and take into account all forces acting on the fluid in the control volume at a particular instant and at that same instant evaluate the momentum fluxes into and out of the control volume. We will choose a control volume coinciding with the inside of the pipe walls over the length δL and including the flow cross-section at each end of the pipe section δL long. This control volume, the fluid in it, and the external forces acting are shown below.



The side shear force caused by friction will be neglected because its size is limited by a very small δL. Also, because we are considering only relatively rigid pipe (steel, concrete, etc.), the pipe bulge will be very small and F_3 will also be negligible.

Application of Equation 5.2 gives

$$F_1 - F_2 = Q\rho(V - \Delta V + a - V - a) = Q\rho(-\Delta V)$$

where $Q\rho = (V + a)A\rho$

If the pressure at (1) were p_o then the pressure at (2) would be $p_o + \Delta p$.

$$p_oA - (p_o + \Delta p)(A + \delta A) = (V + a)A\rho(-\Delta V)$$

Expanding this equation and recognizing that $\Delta p = \gamma\Delta H$ and δA is very small compared to ΔH, A, and γ, we can neglect the small terms with the result

$$-\Delta H\gamma A = (V + a)A\rho(-\Delta V)$$

In slightly different form, this equation can be written

$$\Delta H = \frac{\rho}{\gamma}\Delta V(V + a)$$

or

$$\Delta H = \frac{a\Delta V}{g}\left(1 + \frac{V}{a}\right) \tag{5.3}$$

In most cases involving rigid pipes (even PVC with a wave speed of only 1200 fps), the value of V/a is less than 0.01. Accordingly, Equation (5.3) is generally used (and is always used in this text) as

$$\boxed{\Delta H = \frac{a}{g}\Delta V} \tag{5.4}$$

It is clear from Equation (5.4) that ΔH depends on the wave speed a and cannot be determined until a value of a is established.

5.2 THE WAVE SPEED FOR THIN-WALLED PIPES

To develop an equation for the wave speed a we will consider conservation of mass in the section of pipe δL long, which was used in the previous section to find an equation for ΔH. The procedure used will be to examine

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TABLE C-6
MODULUS OF ELASTICITY, U.S. UNITS, FOR METALS

Material	E = Modulus of Elasticity, Msi (Millions of psi), at Temperature, °F									
	−425	−400	−350	−325	−200	−100	70	200	300	400
Ferrous Metals										
Gray cast iron	...	...	...	...	...	...	13.4	13.2	12.9	12.6
Carbon steels, C ≤ 0.3%	31.9	...	...	31.4	30.8	30.2	29.5	28.8	28.3	27.7
Carbon steels, C > 0.3%	31.7	...	...	31.2	30.6	30.0	29.3	28.6	28.1	27.5
Carbon-moly steels	31.7	...	...	31.1	30.5	29.9	29.2	28.5	28.0	27.4
Nickel steels, Ni 2%–9%	30.1	...	...	29.6	29.1	28.5	27.8	27.1	26.7	26.1
Cr-Mo steels, Cr ½%–2%	32.1	...	...	31.6	31.0	30.4	29.7	29.0	28.5	27.9
Cr-Mo steels, Cr 2¼%–3%	33.1	...	...	32.6	32.0	31.4	30.6	29.8	29.4	28.8
Cr-Mo steels, Cr 5%–9%	33.4	...	...	32.9	32.3	31.7	30.9	30.1	29.7	29.0
Chromium steels, Cr 12%, 17%, 27%	31.8	...	...	31.2	30.7	30.1	29.2	28.5	27.9	27.3
(5) Austenitic steels (TP304, 310, 316, 321, 347)	30.8	...	...	30.3	29.7	29.0	28.3	27.6	27.0	26.5
Copper and Copper Alloys (UNS Nos.)										
Comp. and leaded-Sn bronze (C83600, C92200)	...	...	...	14.8	14.6	14.4	14.0	13.7	13.4	13.2
Naval brass, Si- & Al-bronze (C46400, C65500, C95200, C95400)	...	...	...	15.9	15.6	15.4	15.0	14.6	14.4	14.1
Copper (C11000)	...	...	...	16.9	16.6	16.5	16.0	15.6	15.4	15.0
Copper, red brass, Al-bronze (C10200, C12000, C12200, C12500, C14200, C23000, C61400)	...	...	...	18.0	17.7	17.5	17.0	16.6	16.3	16.0
90Cu-10Ni (C70600)	...	...	...	19.0	18.7	18.5	18.0	17.6	17.3	16.9
Leaded Ni-bronze	...	...	...	20.1	19.8	19.6	19.0	18.5	18.2	17.9
80Cu-20Ni (C71000)	...	...	...	21.2	20.8	20.6	20.0	19.5	19.2	18.8
70Cu-30Ni (C71500)	...	...	...	23.3	22.9	22.7	22.0	21.5	21.1	20.7
Nickel and Nickel Alloys (UNS Nos.)										
Monel 400 N04400	28.3	...	...	27.8	27.3	26.8	26.0	25.4	25.0	24.7
Alloys N06007, N08320	30.3	...	...	29.5	29.2	28.6	27.8	27.1	26.7	26.4
Alloys N08800, N08810, N06002	31.1	...	...	30.5	29.9	29.4	28.5	27.8	27.4	27.1
Alloys N06455, N10276	32.5	...	...	31.6	31.3	30.6	29.8	29.1	28.6	28.3
Alloys N02200, N02201, N06625	32.7	...	...	32.1	31.5	30.9	30.0	29.3	28.8	28.5
Alloy N06600	33.8	...	...	33.2	32.6	31.9	31.0	30.2	29.9	29.5
Alloy N10001	33.9	...	...	33.3	32.7	32.0	31.1	30.3	29.9	29.5
Alloy N10665	34.2	...	...	33.3	33.0	32.3	31.4	30.6	30.1	29.8
Unalloyed Titanium										
Grades 1, 2, 3, and 7	...	...	...	...	...	...	15.5	15.0	14.6	14.0

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R.F. #4
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PIPE DATA

Carbon and Alloy Steel — Stainless Steel

(also see next three pages)

Nominal Pipe Size (Inches)	Outside Diam. (Inches)	Identification: Steel: Iron Pipe Size	Identification: Steel: Sched. No.	Identification: Stainless Steel Sched. No.	Wall Thickness (t) Inches	Inside Diameter (d) Inches	Area of Metal Square Inches	Transverse Internal Area (a) Square Inches	Transverse Internal Area (A) Square Feet	Moment of Inertia (I) Inches⁴	Weight Pipe Pounds per foot	Weight Water Pounds per foot of pipe	External Surface Sq. Ft. per foot of pipe	Section Modulus $\left(2\frac{I}{O.D.}\right)$
1/8	0.405	...	...	10S	.049	.307	.0548	.0740	.00051	.00088	.19	.032	.106	.00437
		STD	40	40S	.068	.269	.0720	.0568	.00040	.00106	.24	.025	.106	.00523
		XS	80	80S	.095	.215	.0925	.0364	.00025	.00122	.31	.016	.106	.00602
1/4	0.540	...	...	10S	.065	.410	.0970	.1320	.00091	.00279	.33	.057	.141	.01032
		STD	40	40S	.088	.364	.1250	.1041	.00072	.00331	.42	.045	.141	.01227
		XS	80	80S	.119	.302	.1574	.0716	.00050	.00377	.54	.031	.141	.01395
3/8	0.675	...	...	10S	.065	.545	.1246	.2333	.00162	.00586	.42	.101	.178	.01736
		STD	40	40S	.091	.493	.1670	.1910	.00133	.00729	.57	.083	.178	.02160
		XS	80	80S	.126	.423	.2173	.1405	.00098	.00862	.74	.061	.178	.02554
1/2	0.840	...	...	5S	.065	.710	.1583	.3959	.00275	.01197	.54	.172	.220	.02849
		...	...	10S	.083	.674	.1974	.3568	.00248	.01431	.67	.155	.220	.03407
		STD	40	40S	.109	.622	.2503	.3040	.00211	.01709	.85	.132	.220	.04069
		XS	80	80S	.147	.546	.3200	.2340	.00163	.02008	1.09	.102	.220	.04780
		...	160	...	.187	.466	.3836	.1706	.00118	.02212	1.31	.074	.220	.05267
		XXS	...	...	.294	.252	.5043	.050	.00035	.02424	1.71	.022	.220	.05772
3/4	1.050	...	...	5S	.065	.920	.2011	.6648	.00462	.02450	.69	.288	.275	.04667
		...	...	10S	.083	.884	.2521	.6138	.00426	.02969	.86	.266	.275	.05655
		STD	40	40S	.113	.824	.3326	.5330	.00371	.03704	1.13	.231	.275	.07055
		XS	80	80S	.154	.742	.4335	.4330	.00300	.04479	1.47	.188	.275	.08531
		...	160	...	.219	.612	.5698	.2961	.00206	.05269	1.94	.128	.275	.10036
		XXS	...	...	.308	.434	.7180	.148	.00103	.05792	2.44	.064	.275	.11032
1	1.315	...	...	5S	.065	1.185	.2553	1.1029	.00766	.04999	.87	.478	.344	.07603
		...	...	10S	.109	1.097	.4130	.9452	.00656	.07569	1.40	.409	.344	.11512
		STD	40	40S	.133	1.049	.4939	.8640	.00600	.08734	1.68	.375	.344	.1328
		XS	80	80S	.179	.957	.6388	.7190	.00499	.1056	2.17	.312	.344	.1606
		...	160	...	.250	.815	.8365	.5217	.00362	.1251	2.84	.230	.344	.1903
		XXS	...	...	.358	.599	1.0760	.282	.00196	.1405	3.66	.122	.344	.2136
1¼	1.660	...	...	5S	.065	1.530	.3257	1.839	.01277	.1038	1.11	.797	.435	.1250
		...	...	10S	.109	1.442	.4717	1.633	.01134	.1605	1.81	.708	.435	.1934
		STD	40	40S	.140	1.380	.6685	1.495	.01040	.1947	2.27	.649	.435	.2346
		XS	80	80S	.191	1.278	.8815	1.283	.00891	.2418	3.00	.555	.435	.2913
		...	160	...	.250	1.160	1.1070	1.057	.00734	.2839	3.76	.458	.435	.3421
		XXS	...	...	.382	.896	1.534	.630	.00438	.3411	5.21	.273	.435	.4110
1½	1.900	...	...	5S	.065	1.770	.3747	2.461	.01709	.1579	1.28	1.066	.497	.1662
		...	...	10S	.109	1.682	.6133	2.222	.01543	.2468	2.09	.963	.497	.2598
		STD	40	40S	.145	1.610	.7995	2.036	.01414	.3099	2.72	.882	.497	.3262
		XS	80	80S	.200	1.500	1.068	1.767	.01225	.3912	3.63	.765	.497	.4113
		...	160	...	.281	1.338	1.429	1.406	.00976	.4824	4.85	.608	.497	.5078
		XXS	...	...	.400	1.100	1.885	.950	.00660	.5678	6.41	.42	.497	.5977
2	2.375	...	...	5S	.065	2.245	.4717	3.958	.02749	.3149	1.61	1.72	.622	.2652
		...	...	10S	.109	2.157	.7760	3.654	.02538	.4992	2.64	1.58	.622	.4204
		STD	40	40S	.154	2.067	1.075	3.355	.02330	.6657	3.65	1.45	.622	.5606
		XS	80	80S	.218	1.939	1.477	2.953	.02050	.8679	5.02	1.28	.622	.7309
		...	160	...	.344	1.687	2.190	2.241	.01556	1.162	7.46	.97	.622	.979
		XXS	...	...	.436	1.503	2.656	1.774	.01232	1.311	9.03	.77	.622	1.104
2½	2.875	...	...	5S	.083	2.709	.7280	5.764	.04002	.7100	2.48	2.50	.753	.4939
		...	...	10S	.120	2.635	1.039	5.453	.03787	.9873	3.53	2.36	.753	.6868
		STD	40	40S	.203	2.469	1.704	4.788	.03322	1.530	5.79	2.07	.753	1.064
		XS	80	80S	.276	2.323	2.254	4.238	.02942	1.924	7.66	1.87	.753	1.339
		...	160	...	.375	2.125	2.945	3.546	.02463	2.353	10.01	1.54	.753	1.633
		XXS	...	...	.552	1.771	4.028	2.464	.01710	2.871	13.69	1.07	.753	1.997
3	3.500	...	...	5S	.083	3.334	.8910	8.730	.06063	1.301	3.03	3.78	.916	.7435
		...	...	10S	.120	3.260	1.274	8.347	.05796	1.822	4.33	3.62	.916	1.041
		STD	40	40S	.216	3.068	2.228	7.393	.05130	3.017	7.58	3.20	.916	1.724
		XS	80	80S	.300	2.900	3.016	6.605	.04587	3.894	10.25	2.86	.916	2.225
		...	160	...	.438	2.624	4.205	5.408	.03755	5.032	14.32	2.35	.916	2.876
		XXS	...	...	.600	2.300	5.466	4.155	.02885	5.993	18.58	1.80	.916	3.424

Identification, wall thickness and weights are extracted from ANSI B36.10 and B36.19. The notations STD, XS, and XXS indicate Standard, Extra Strong, and Double Extra Strong pipe respectively.

Transverse internal area values listed in "square feet" also represent volume in cubic feet per foot of pipe length.

BEST AVAILABLE COPY

F.2.5 CALCULATION OF TRANSFER LINE HEAT UP/HEAT LOSS

F.3.1 ELECTRICAL DISTRIBUTION SYSTEM - DAPPER MODEL RESULTS (TO BE PRODUCED)

CORRESPONDENCE DISTRIBUTION COVERSHEET

Author	Addressee	Correspondence No
M. W. Manderbach	I. G. Papp	CO-98-TWRS-391 August 13, 1998

Subject TASK ORDER 44-10-02, PREPARE PIPING AND INSTRUMENTATION DIAGRAMS

INTERNAL DISTRIBUTION

Name	Location	w/att
Fluor Daniel Northwest, Inc.		
Bowman, M. J.	G3-12	
Manderbach, M. W.	B4-57	X (summary results only)
Newhouse, R. K.	G3-08	
Steen, R. T.	B4-57	
LMHC Project Files	B4-57	X (on disk)
Lockheed Martin Hanford, Corp.		
Cortez, L. N.	H7-08	
Numatec Hanford Corporation		
Carlson, A. B.	H5/49	(summary results only)
Papp, I. G. (Original)	H5-49	X
Peters, B. B.	H5-03	(summary results only)
E-2 Consulting Engineers		
Poe, J.	1201 Jadwin	X (summary results only)

(POC: Sue St.Mary, 376-0941, B4-57)

FLUOR DANIEL NORTHWEST, INC.
1100 Jadwin
P.O. Box 1050
Richland, Washington 99352-1050

August 13, 1998

LMHC96W0-0006
CO-98-TWRS-391

Mr. I. G. Papp
Numatec Hanford Corporation
P.O. Box 1300
Richland, Washington 99352-1300

Dear Mr. Papp:

TASK ORDER 44-10-02, PREPARE PIPING AND INSTRUMENTATION DIAGRAMS

Response Requested By: N/A

Responds To: N/A

Enclosed is a load flow and voltage drop analysis of 13.8 kV line number C8-I6, which provides electrical power to the tank farms in the 200 East Area. The analysis evaluates the effects of running nine mixing pumps simultaneously and starting nine mixer pumps simultaneously.

Please feel free to contact Keith Newhouse at 376-2392 or myself at 373-2198 if you have any questions.

Sincerely,

M. W. Manderbach
Project Manager

MWM:sst

Attachment

DAPPER STUDY OF 13.8KV LINE C8-L6

Description of Study

Line C8-L6 originates at Substation 251-W located north of the 200 East and 200 West areas. It travels east and southeast to the 200 East Area, continues southeast toward the east side of 200 East and then turns south to the general area of the Purex plant. This portion of the line is constructed of #4/0 copper. The line is tapped west of the AN tank farm with a #2/0 copper line which then splits into a #2 ACSR (aluminum conductor, steel reinforced) branch that serves AN and AZ farms and a #4 ACSR branch that travels south down Buffalo Avenue and then east to serve AY, AW, and AP tank farms and other loads in the vicinity of the 242-A evaporator, Purex plant, grout vaults, and points east. The line was modeled using SKM Systems Analysis, Inc. DAPPER software in order to evaluate its performance under various loading conditions.

The 251-W bus voltage used in the studies was 1.07 per unit, or 14,766 volts as was recommended by DynCorp Electrical Utilities group for DAPPER studies that were previously performed for lines C8-L5 and C8-L8 in support of the Project W-505 CDR.

ANSI Standard C84.1 requires that electric supply systems (utilities) be so designed and operated that most service voltages will not be less than 13,460 volts for systems with a nominal voltage of 13,800 volts. This represents a maximum voltage drop of 2.5% for the purposes of the DAPPER analysis.

The basic model represents the line in its present configuration, loaded to conform to Electrical Utilities' historical watthour meter data for the last two years, and with no mixing pumps in operation. Under these conditions the voltage drop in the vicinity of the tank farms is less than 1%.

Another model was created (by copying the electronic file for the basic model and adding data) by adding two 300 HP mixer pumps at AZ farm, four 150 HP mixer pumps at AY farm, two 300 HP mixer pumps at AW farm, and one 300 HP mixer pump at AP farm. These pumps were modelled as if they were running at full speed with all other loads the same as modeled in the basic model. Under these conditions the voltage drops on the secondary (480 volt) sides of the transformers serving the mixing pumps increased to approximately 7.5%.

A third model was created that is the same as the second model except that in this case the mixer pump motors were modeled as starting rather than running at steady state. Starting currents were taken as 150% of full load amperes because the motors will be controlled by variable speed drives (VSDs) whose output current is limited to 150% of normal. Under these conditions voltage drops increased to approximately 15%.

Discussion

As may be seen, the voltage drops resulting when all the motors are running or starting exceed the value allowed by ANSI C84.1.

Motor starting is a transient condition and the C84.1 allowable isn't really relevant, the primary concern being whether the voltage will be adequate to actually start the motors. 85% of nominal voltage probably is adequate to start the motors, but what the motor actually sees is dependent on the characteristics of the VSD controlling it so this situation is beyond the scope of this study. It does not seem credible that this event would ever occur anyway.

DynCorp Electrical Utilities group requires that service transformers be procured with adjustable voltage taps and so it might be possible to reduce the voltage drops at the transformer secondaries to about 2.5% by adjusting the taps. However, this would not bring the service voltage into conformance with ANSI C84.1.

Some improvement in the voltage drops could be achieved by replacing the #4 ACSR portion of the line with larger conductors, but the gain would not be sufficient to bring the system into conformance with code because most of the voltage drop occurs in the #4/0 copper portion of the line between substation 251-W and the tap west of AN farm. Rebuilding that portion of the line with larger conductors is probably not realistic since it is several miles long.

Probably the best solution would be to disconnect AW and AP farms from line C8-L6 and connect them to line C8-L5, which is very similar to line C8-L6 but has very little existing load. Line C8-L5 presently exists adjacent to AW farm and the work described in the W-505 CDR includes disconnecting the portion of line C8-L6 east of Canton Avenue from line C8-L6 and connecting it to line C8-L5 (this includes the AP farm tap). Thus, 900 HP would be removed from line C8-L6 and relocated to line C8-L5. If two of the postulated mixing pumps were in AN farm instead of AW farm, AY farm could be connected to line C8-L5 without great difficulty. The appropriate solution is dependent on what effect recent changes in strategic plans will have on the waste transfer schedule. In accordance with the Project W-505 CDR, line C8-L5 will be used to supply power for construction of the private contractor's plant, so that may affect the availability of the line for the use of the tank farms.

Line C8-L8 also exists in the vicinity of the PUREX plant and the Project W-505 CDR includes extending it east to the private contractor's plant to provide backup construction power. In accordance with the Project W-519 CDR it will also supply power for pumping from tanks 106-AP and 108-AP to the private contractors' pilot plants. It has less capacity than lines C8-L5 and C8-L6, but it presently has no load.

If the possibility of transferring loads to lines C8-L5 and C8-L6 is to be considered, the DAPPER models of these lines that were created for the Project W-505 and W-519 studies should be updated and refined to permit evaluation of the waste transfer scenarios that are postulated.

200 East Line C8-L6 Studies

PURPOSE:

To study the impacts of simultaneously starting and running 5-300HP and 4-150HP mixer pumps located in Tank Farms AY, AZ, AW, and AP on the 251-W substation 13.8 kV line C8-L6.

METHODOLOGY:

An SKM PowerTools for Windows (PTW) line C8-L6 one-line model (C8l6org) was created utilizing the data found on the Essential Drawing H-2-818278, Sheet 5, Rev 2 & Sheet 6, Rev 6. The line segment impedances were validated for accuracy and found to be correct with the exception of the parallel segments of #4/0 Cu. The actual impedance for these parallel segments is a little higher than originally calculated by Electric Utilities (EU). The fault calculations were run and found to be very close to those found on the Essential Drawing. The values were a little lower due to the increase in parallel line impedances.

A new C8-L6 model was created from a copy of C8L6org and was then updated to include field verified transformer data, which yielded a net gain of approximately 6.8 MVA of additional loads and other corrections. It was then load factored to reduce the connected load (26,660 Kva) to a level consistent with its metered two year monthly maximum demand data. The average over a two year period to date, was 4300 kW (4778 Kva @ 90% PF). An energy audit load diversity factor of 20% yielded the closest results to the average monthly maximum demand, which was 4783.6 Kva at 94.5% power factor (200.1 amperes @ 13.8 KV).

Two study models were then created from this C8-L6 model to include the AY, AZ, AW, and AP tank farm mixer pumps and two additional transformers. These models were C8L6mr for all mixers running, and C8L6ms for all mixer pumps starting. The analysis scenarios run were first a baseline (C8-L6) with no mixer pumps, second was all mixers running (C8L6mr) and third (C8L6ms) was all mixers starting. In the mixers starting scenario, the starting currents were limited to the VFD 150% maximum values.

GIVEN INFORMATION AND ASSUMPTIONS:

The impact loads included in these scenarios are all located on the line C8-L6 fused switch C8X111 tap located west of Buffalo and north of MO-277A. This tap comes in as #2/0 copper to Buffalo and ties into a #4 ACSR circuit that goes south to the AY, AW, and AP tank farms, and a #2 ACSR that heads east and northeast to the AN and AZ tank farms.

The 13.8 kV driving voltage, for substation 251-W that feeds line C8-L6, was set to 1.07 per unit, as recommended by DynCorp Electric Utilities.

The 1350 Kvar capacitor bank C5498, located north of 4th street and three spans west of MO-405, was included as operational in all of the studies.

RESULTS AND CONCLUSIONS:

The following table shows the two major weak points in line C8-L6, their respective currents and cable/wire ratings. Leaving the 251-W substation is limited by the 15 KV, 500Kcmil, copper, Anaconda EP insulated cable. The

200 East Line C8-L6 Studies

switch C8X111 circuit is limited by the #4 ACSR running south down Buffalo into the AY, AW, and AP farm areas.

	251-W Bus 6700			C8x111 Bus 6720		
	Amperes	PF%	Rating	Amperes	PF%	Rating
Baseline	200.1	94.5	465	64.7	80.0	140
Motors Running	309.89	84.0	465	119.91	79.0	140
Motors Starting	339.29	62.0	465	155.7	34.0	140

The Load Flow Study results, for the motors running, indicates that line C8-L6 13.8 KV voltage drops approximately 3.71% from the 251-W substation to the C8X111 switch tap, and to around 5% at the AP tank farm. The bulk of the voltage drop (74%) is in the #4/0 Cu line from 251-W to C8X111 switch.

Increasing the size of the #4 ACSR on Buffalo will help improve voltage regulation some, maybe .5% at AP. The main reason for recommending its size be increased to maybe #2/0 ACSR is for additional capacity, as the #4 ACSR is being pushed to its current limit of 140 amperes.

Under normal loading conditions with no motors, the voltage drops at these same locations are negligible.

Assuming full load conditions with the mixer pumps running and starting, the table below indicates the 480 Vac voltage drops at the main distribution panels with the main transformer taps set at nominal:

	AZ Tank Farm	AY Tank Farm	AW Tank Farm	AP Tank Farm
Baseline	.32%	No Xfmr	No Xfmr	.94%
Running	7.31%	7.33%	7.91%	7.15%
Starting	14.69%	14.62%	15.12%	12.55%

Increasing the Buffalo circuit to #2/0 ACSR will reduce motor running 13.8 KV line voltage drop by approximately .5%. This will help decrease the 480 Vac main distribution panel drops by approximately .5% to .7%.

F.4.1 ASSESSMENT OF AVAILABLE TANK CAMERA SYSTEMS

July 1998

Mr. Ivan Papp
Numatec Hanford Corporation

Mr. Papp,

I spent several years working with visual imagery, from designing systems for access into areas where human access is impossible or has the potential for extreme danger, to the lighting requirements for various atmospheres. I managed the Remote Surveillance group in Characterization Project Operations (CPO) for the tank farms at Hanford, this was the group that introduced along with several other systems, stereo vision into the Hanford tanks giving engineering management an actual three dimensional look at the waste inside the huge Underground Storage Tanks (UST's). This was especially helpful for sampling activities, in discovering which areas in the tank had the waste in mounds and which areas were void of waste, aiding in the decision of which riser to deploy through.

In this letter you will find some information on available camera systems on the market, and which systems currently exist in the Hanford Tank Farms at the Department Of Energy (DOE) site in Richland, WA. This letter also consists of my recommendations and the estimate of costs for deploying the cameras already utilized at Hanford.

INTRODUCTION:

The Hanford Tank Farms have several mobile and permanently installed camera systems. The permanent cameras with lights are installed into tanks 241-SY-101, 103, 241-AW-101, 241-AN-103, 104, 105 and *107. These systems have their equipment located at the specified farm where they can be operated when the need arises. The mobile systems are transferred from tank to tank as necessary by way of a covered vehicle which carries all the essential equipment for operation.

SUMMARY:

The permanent cameras have been installed into the tanks through a twenty inch riser using a riser adapter and placing it on the 42 inch opening. The adapter typically has three access ports, a twenty inch, 12 inch and an eight inch port. These cameras have a life of approximately two years at 200R/hr.

There are two color cameras with lights installed in SY-101 both on the same equipment, one is an overview camera for general viewing of the waste and tank walls. This system is installed into the 42 inch riser number 5A which has a multi-port riser adapter on it with the camera system installed through the twenty inch port . This system was installed due to the occasional tank "rollover", an event which releases trapped gasses under the waste. It was believed necessary to install a system that could be used at anytime without tank farm entry (after initial installation), to observe these significant events. From the successes at SY-101, other systems were obtained and justified for installation into other various underground storage tanks.

The only documentation that mentions the use of permanently installed cameras has been written for SY-101 which is not controlled by the Basis for Interim Operation (BIO), HNF-SD-WM-BIO-001. SY-101 has it's own specific stand alone safety requirements. The BIO however, does mention cameras, lights and other equipment necessary when there is waste intrusive work commencing in the tanks, these comments are only for the safety aspects of the systems in preventing sparks caused from static, electrical or mechanical means. There is no mention in the BIO with regard to specific size or installation method or whether the camera be permanent, temporary or mobile.

See attachment "A": "Item classification: Non-de minimus" appendix E from the BIO.

EXISTING CAMERAS / CONFIGURATION:

Below is a list of the tanks with a permanently installed camera system and their configuration. All systems in flammable gas atmospheres must be qualified as class 1 division 1 group B.

SY-103, AW-101, AN-103, 104, and 105 have the same configuration as SY-101 as they also use multi-port risers and are installed through the 20 inch access port. The exception is the use of an overview camera which only SY-101 has. SY-103 is installed into riser 5B; AW-101 riser 5B; AN-103 riser 5B; AN-104 riser 5B and AN-105 riser 5A.. AN-107 has an unqualified (does not meet the flammable gas requirements) color camera system with lights installed into riser 7A which is a twelve inch riser. All the tanks listed above with the exceptions of SY-101 and C-106 are considered idle, or on "standby". Maintenance specifications for these particular cameras suggest that they be replaced / repaired annually. Interviews with individuals working with the group assigned the camera replacement work allude to the Maintenance Management Procedure as the document controlling that activity. The apparent lack of funds for this preventive maintenance is what has caused their current "standby" condition.

Attachment "B" is a section from the Maintenance Management Procedure, included is a copy of a message explaining why the cameras have been shut down.

AVAILABILITY:

There are camera systems with lights with the ability to be deployed through risers of less than six inches and some in as small as 4 inches. These cameras would lack the overall lighting used on the bigger permanent systems, though there are intrinsically safe lights available on the market which would still need a twelve inch access port and with the camera in one riser and the light in another there would be adequate resolution and two less risers available. CPO has successfully deployed both the light and the camera in the same twelve inch riser allowing CPO sampling teams another option for access into the tanks by freeing one other riser during filming. There are smaller diameter lights being developed to access a 4 inch riser and to be qualified for flammable gas atmospheres with one thousand watts of high intensity lighting by the end of this calendar year. These smaller diameter lights could possibly allow access by both a mobile camera and light through a four inch riser again giving operating crews even more desirable options to access the tank.

The smaller mobile cameras also lack the shielding the larger permanent cameras have (which is partially the reason for the permanent camera size) but, could be removed when not in use, thus potentially extending the life of the system. The flaw with deploying and removing these mobile systems is that if work was continuing on any of the tanks with trapped gasses the tank could not be opened during that "rollover" event, therefore leaving the camera exposed to the radiation. The scheduling for deployment would also have to be very precise.

FUTURE PROJECTS:

Project W-151 plans to install a color camera system with lights into AZ-101 riser 16B fiscal year 1998.

Project W-211 plans to install color camera systems with lights starting in fiscal year 1999 and going through fiscal year 2001, beginning with AP-102 and 104, both into 42 inch risers numbered; 0 degree riser 5, (the most northern 42 inch riser). By fiscal year 2000 current plans are to have a system installed into AZ-102, and by fiscal year 2001 install a system into SY- 102 in the central pump pit using the same configuration as SY-101.

Project W-320 installed a mobile color camera system with lights into C-106 riser number 7, a twelve inch riser. They are currently looking for another mobile system.

SCHEDULING AND COSTS:

Consider the cost of permanent cameras mounted into each of the 177 UST's at Hanford, (this is very unlikely) but, if the task were to arise for a visual scan of each UST the cost would be astronomical. Each system costing well into the hundreds of thousands of dollars to purchase, install and operate not to mention the time, scheduling, additional hardware such as riser adapters, configuration changes and engineered drawings updated for each tank. These costs are also driven upwards due the severe requirements put on the flammable gas tanks.

Mobile systems available today, designed and qualified for the flammable gas requirements of the Hanford tanks cost between twenty two thousand and 45 thousand dollars to purchase. Operations personnel are already trained to operate two of these systems, procedures have been written and there are experienced individuals in the use of these systems. When new systems are introduced operations includes the training in their "Continuing Training" program which is required on a monthly basis to keep all persons who operate equipment in CPO at the Tank Farms familiar with their roles and responsibilities.

Wally Kennedy Field Sampling Manager and responsible manager for the In-Tank videos for CPO, gave me an estimate of one day of video inside an UST. This estimate includes a crew of approximately seven to 9 people, writing a work package, set-up of equipment at riser on tank, deploy camera and remove equipment for roughly fifteen thousand dollars. A work package is only part of the initial costs and every day thereafter could be as little as 5 to seven thousand dollars. (Contingencies of course are not included). George Stanton Programmatic Manager CPO estimates that if given between 30 and sixty days that work can be on the CPO schedule. (This also depends on time of year and strain already on the schedule of completing any milestones).

Due to the costs, consideration to ongoing operations and the consensus from Tank Farm management, several mobile systems could be purchased and utilized on a regular basis and on various forms of tasks without depleting the options for Tank Farms Operations access into the tank while remaining cost effective.

RECOMMENDATIONS:

My recommendations are to use mobile camera systems for any projects requiring the use of visual imagery during the particular activity as long as there is the option to have the camera removed from direct radiation exposure while the project is in "down" mode. There are advantages to having the larger shielded cameras, though it is not necessary for those systems to be permanently installed,(potentially hindering operational alternatives for deploying equipment into the tanks). An example of this; a project continuing for an extended period of time without frequent delays. (The adverse effect of course is a larger diameter riser will need to be selected). Even in this situation it is highly recommended that the system be capable of being removed, extending it's life, while other accesses into the underground storage tanks remain available for operations.

INTERVIEWS:

** Interviews conducted with operations management show a need to use visual aides during waste intrusive activities, those visuals are required according the BIO, (as stated above). Operations agrees that the permanently installed cameras hinder the potential use of these risers in the future, (with the exception of SY-101) and serve no practical purpose unless there is a mission for that specific tank. Leaving them to sit and take a direct dose especially while idle is a mis-use of funds and equipment. Portable video systems would serve the same purpose, can be removed and re-installed into another access port 6 inches to four inches in diameter in a matter of hours allowing for more access into the tanks at various positions for other activities.

Attachment "C" has pictures of the permanently installed camera system prior to deployment, a sketch of the camera system and where to find drawings and vendor information.

Attachment "D" is a sketch of the mobile camera system currently being used in the Tank Farms CPO organization.

* The camera installed into 241-AN-107 has not been qualified for use in flammable gas atmospheres.

** These comments are not quotes but, information gathered from the interviews. There is a mutual agreement among operations management regarding the permanently installed cameras in the Hanford tanks .

Sincerely,

D C Langlois
Project Manager
E2 Consulting Engineers, Inc.

ATTACHMENT "A"

ITEM CLASSIFICATION: NON-DE MINIMUS

ITEM NUMBER: 27

EQUIPMENT: Cover blocks, riser flanges, shield plugs, and tank installed waste intrusive and non waste intrusive equipment items (e.g., thermocouple trees, steel LOWs, pumps, manual tapes, FICs, ENRAFs, radar gauges, heated vapor probes, MITs, corrosion probes, VDTTs, water lances, void fraction meter, core sampling drill string, saltwell screens, dip tubes, cameras, lights, viscometer, auger sampler)

CATEGORY: Mechanical Spark Potential

USE:

Items are used for various purposes in risers and pits, or are equipment installed or removed in tanks to perform various functions.

APPLICABLE CONTROL NOT MET:	WHEN CONTROL NOT MET:
ICS 2 #1	FG 1 Ex Tank FG 1,2 Dome Intrusive FG 3 Dome Intrusive (LWD, GWD) FG 2 Ex Tank (GWD) Waste Intrusive Regions

DISCUSSION OF FLAMMABLE GAS JCO APPLICABILITY:

These are potential mechanical spark sources during seismic events, large GREs, and during installation, removal, or movement during use of various tools and equipment. Many are made of carbon steel. These items are inserted into or attached to the top of a riser or pit opening. Where required by the Flammable Gas JCO, these items are also bonded. Installation, removal, and use of these items are considered routine operations. The risk of mechanical sparks is minimized by use of practical measures such as controlling the rate of insertion or removal. Monitoring is done during installation, removal, and movement, and these are stopped if required by flammable gas levels.

RISK ACCEPTANCE:

See risk acceptance writeup starting on next page.

IMPACT OF NOT ACCEPTING RISK OF CONTINUED USE:

<u>Facility Group 1 Tanks</u>-Will shut down most pit or riser installation work and halt installation of equipment into tanks.

<u>Facility Group 2 Tanks</u>-Will shut down most pit or riser installation work and halt installation of equipment into tanks.

<u>Facility Group 3 or other Tanks</u>-Will restrict or shut down all waste intrusive installations and removals.

REQUESTED APPROVAL FROM DOE:

Presence of non-spark resistent materials for installed equipment in locations and during activities as listed below. As this portion of the exception applies to the presence of installed equipment, no monitoring is required by this portion of the exception.

Installation and removal or movement during use of equipment fabricated from non-spark resistent materials when practical measures to control mechanical spark potential are applied and while performing flammable gas monitoring controls [A] as appropriate for the location and activity type in:

1) FG 1 tanks during Ex Tank activities
2) FG 1,2 tanks during Dome Intrusive activities
3) FG 3 tanks during Dome Intrusive local and global waste disturbing activities
4) FG 2 Ex Tank regions during global waste disturbing activities
5) Waste Intrusive Regions

c. Motion occurs during the installation of equipment (e.g., as it is lowered into the tank through a riser). Practical measures to reduce the likelihood of a mechanical spark during equipment installation shall be included in equipment design, work packages, or installation procedures when such movement has significant potential to cause mechanical sparks. This can include: limiting insertion speeds, water bathing of equipment, prevention of contact with other non-spark resistent materials by use of collars or bumpers, use of critical lift procedures where appropriate. Gas monitoring during these manned activities is performed as required by this JCO.

d. Motion occurs during the removal of equipment (e.g., as it is raised through a riser). Practical measures to reduce the likelihood of a mechanical spark during equipment removal shall be included in equipment design, work packages, or removal procedures when such movement has significant potential to cause mechanical sparks. This can include: limiting removal speeds, water bathing of equipment, prevention of contact with other non-spark resistent materials by use of collars or bumpers, use of critical lift procedures where appropriate. Gas monitoring during these manned activities is performed as required by this JCO.

e. Motion can occur as part of the operation of equipment (e.g., pushing a drill string/core barrel into the waste, [and through a riser], movement of waste characterization sampling devices such as retained gas samplers, void fraction meters, viscometer, auger sampler as they are moved through the waste). These operations are generally performed manually and are limited to low velocities by the nature of the operation. Practical measures to reduce the likelihood of a mechanical spark during equipment movement shall be included in the work packages and installation procedures when such movement has significant potential to cause mechanical sparks. This can include: limiting speeds, water bathing of equipment, prevention of contact with other non-spark resistent materials by use of collars or bumpers, use of critical lift procedures where appropriate. Gas monitoring during these manned activities is performed as required by this JCO.

The risk associated with continuing use of the tools and equipment is further reduced by performing flammable gas monitoring of the work area prior to and during use. This will include monitoring per method [A]. See definition of monitoring methods at the end of this section.

When flammable gas levels reach 25% of the LFL, work ceases as required per the monitoring requirements of this Flammable Gas JCO. The National Fire Protection Association (NFPA 30, 1988) recommends that processes be controlled so that flammable gas concentrations are <25 percent of the lower flammability limit (LFL), when relying upon vapor space flammability levels to preclude the possibility of an ignition. DOE Order 5480.4 requires Hanford waste tanks to be operated within NFPA guidelines. Thus, a control of <25% of the LFL has been established for performing activities in and around Tank Farm facilities. Because of the unpredictable nature of GREs, it is not possible to ensure that 25% of the LFL is never exceeded. Procedures and controls are thus in place to minimize the potential for a tank to exceed 25% of the LFL, and to cease work in areas common with the tank vapor space when the flammable gas concentration exceeds this value. This 25% limit is far below the actual limit at which flammability can occur, and is conservatively chosen to allow for potential measurement.

Monitoring is normally performed with a portable CGM. The CGM is calibrated with pentane and reads high by 100% when monitoring for hydrogen in air. For conservatism, no correction factor is applied in the field to the CGM reading when used for monitoring for personnel protection. Thus a 25% of the LFL reading on a CGM is actually 12.5% of the LFL for hydrogen in air, but is treated as if it were 25%. Depending upon the concentration of the flammable gas constituent and oxidants (ammonia, methane, carbon monoxide, nitrous oxide) a 25% LFL CGM reading will be indicative of 12.5% to approximately 20% flammable gas mixture. The response time of a CGM to an increase in flammable gas concentration is not instantaneous. The CGM starts responding to an increase in flammable gas concentrations almost immediately upon the gas reaching the CGM internals. The internal response time for a CGM to reach a 10% of the LFL indication (5% LFL actual for hydrogen in air) when exposed to a 23% of the LFL pentane mixture (equivalent to a 11.5% of the LFL hydrogen in air mixture) ranged from 7-12 seconds in a number of informal tests. Time to reach the full 23% test gas indication took 20-40 seconds.

If the CGM is drawing a sample out of a tank dome space, the time for the tank vapors to reach the CGM is approximately 26 seconds, based upon the 500 cm^3/min CGM flow and the tubing currently used for flammable gas monitoring. Thus an instantaneous change from 0 to 12.5% of the LFL for hydrogen in air in a tank vapor space (an indicated 25% of the LFL) would not indicate any change at all on a CGM for about 26 seconds. At 26 seconds, the indicated LFL would begin to rise and 33-36 seconds after the step change the CGM would indicate about 10% of the LFL. The CGM would indicate 25% of the LFL approximately 45-65 seconds after the step change.

If the CGM was being used to sample the immediate work area, the 26 second delay would not apply, the CGM would start to rise immediately and a reading of 10% of the LFL would be noted 7-12 seconds after sensing a 25% step increase in the LFL.

ATTACHMENT "B"

Project Hanford Procedures

Topic Listing

Maintenance Management

HNF-PRO-069, Rev 1, Effective: 3/9/98
Technical Authority Approval: JR Barber 2/18/98
Functional Area Manager Approval: TJ Harper 2/27/98
Topic: Maintenance

View Cross Reference and SRID Information	View Change Notice

1.0 PURPOSE

1.1 This document presents the Project Hanford Management Contract (PHMC) policy on maintenance management and work control. It establishes the minimum requirements for a facility or organization maintenance management program. It provides expectations for results of processes by which work activities are identified, initiated, analyzed, planned, approved, scheduled, coordinated, released, performed, completed, and reviewed for adequacy and completeness; to ensure that PHMC work is consistently accomplished safely, in a timely manner, with improved efficiency and increased equipment availability.

This document applies to employees and subcontractors involved in work activities in PHMC-managed areas, facilities, and plants. Work activities include modification, corrective, preventive and predictive maintenance.

2.0 REQUIREMENTS

2.1 General Requirements

NOTE: In order to maintain uniformity and to simplify the process of review and approval, it is recommended that document or change development involve FDH Project Direction Conduct of Operations personnel early in the process.

Each Project Hanford contractor assigned direct responsibility for maintenance of a facility or organization develops, implements, and documents in a Maintenance Implementation Plan (MIP) a program for their facility/organization in conformance with the policy and objectives of this procedure. The program clearly defines:

(1) The structures, systems, and components included, using a graded approach and the requirements derived from Technical Safety Requirements.

(2) The management systems used to control maintenance activities, including the means for monitoring and measuring the effectiveness of the program and the management of maintenance backlog.

(3) The assignment of responsibilities and authority for all levels of the maintenance organization.

(4) Mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

(5) Provisions for identification, evaluation, and correction of possible component, system design, quality assurance, or other relevant problems.

(6) Performance indicators and criteria to be utilized to measure equipment, systems, and personnel effectiveness in maintenance activities.

(7) Interfaces between maintenance and other organizations (i.e., operations, engineering, quality, training, environment, safety, and health).

(8) A self-assessment program to monitor the effectiveness and efficiency of the maintenance program.

(9) Provisions for planning, scheduling, and coordination of maintenance activities.

* Periodic inspections of structures, systems, components, and equipment, particularly those important to the safe and reliable operation of a facility, are performed to determine whether deterioration is taking place and to identify and address technical obsolescence that threatens performance, safety, or facility preservation. Where the potential is identified for any event or condition to significantly affect safety margins, a formal program for resolving the problem is documented and implemented.

2.2 Non-nuclear Facilities

For DOE non-nuclear property for which the PHMC is responsible, a graded approach using the objectives, criteria, and sequence described in the 18 elements presented in Attachment 1 is used in the development and implementation of Maintenance Programs.

NOTE: Non-nuclear facilities may, at their option, prepare and submit for approval a Site Maintenance Plan (SMP) in lieu of a MIP. Refer to Attachment 2. Routing and approvals remain the same as for a MIP.

Exceptions or deviations from the MIP elements are contained within the MIP and are granted by the appropriate DOE RL Management through approval of the MIP.

Author: David_B_Smet@apimc01.rl.gov at ~EXCHANGE
Date: 5/22/97 12:18 PM
Priority: Normal
Receipt Requested
TO: Gerald D (Jerry) Johnson at ~HANFORD11E
TO: Ryan A Dodd at ~HANFORD05E
TO: James J (Jim) Badden at ~WHC103
TO: Shafik H Rifaey at ~HANFORD04B
CC: L T Jr (Tom) Pedersen at ~WHC213
CC: Jim L Castleberry at ~WHC213
CC: Scott M Werry at ~WHC42
CC: Ronald A Harding at ~WHC42
TO: W_M_Michael_Funderburke@apimc01.rl.gov at ~EXCHANGE
Subject: SHUTDOWN OF PERMANENT CAMERA SYSTEMS
---------------------------- Message Contents ----------------------------

Jerry, et al

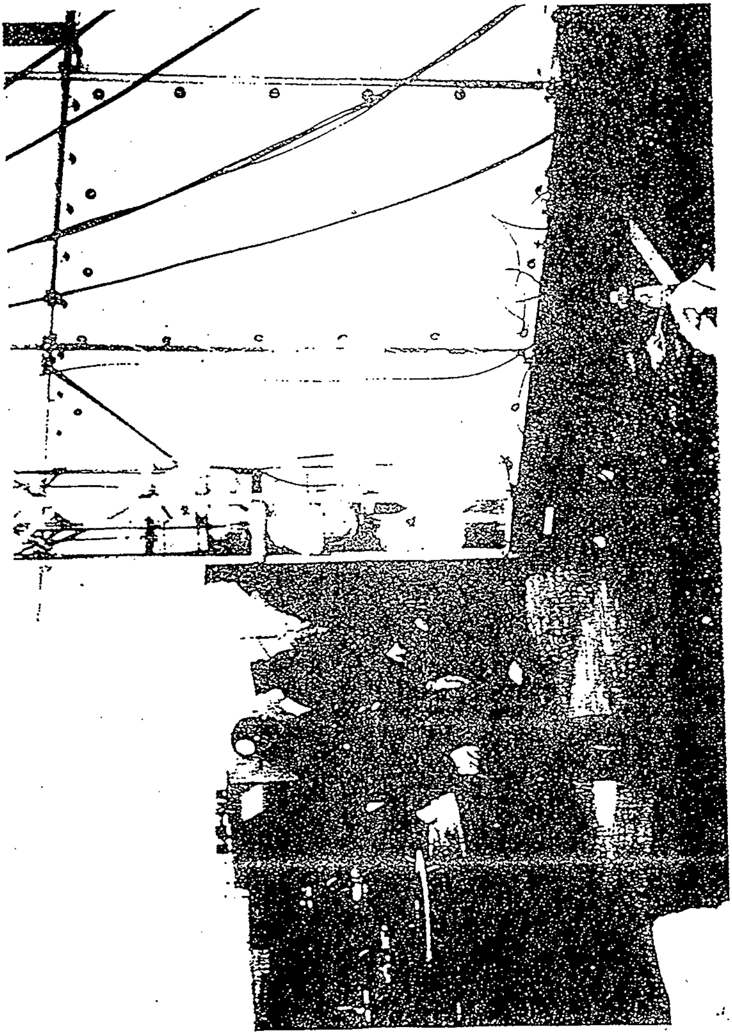
I have been directed to discontinue maintenance on the permanently installed vision systems in the 'Big 6' DST's. Since the SY-101 system maintenance was just recently completed, we will continue to allow that system to operate (it is also required to be active for any intrusive activities by the SAR).

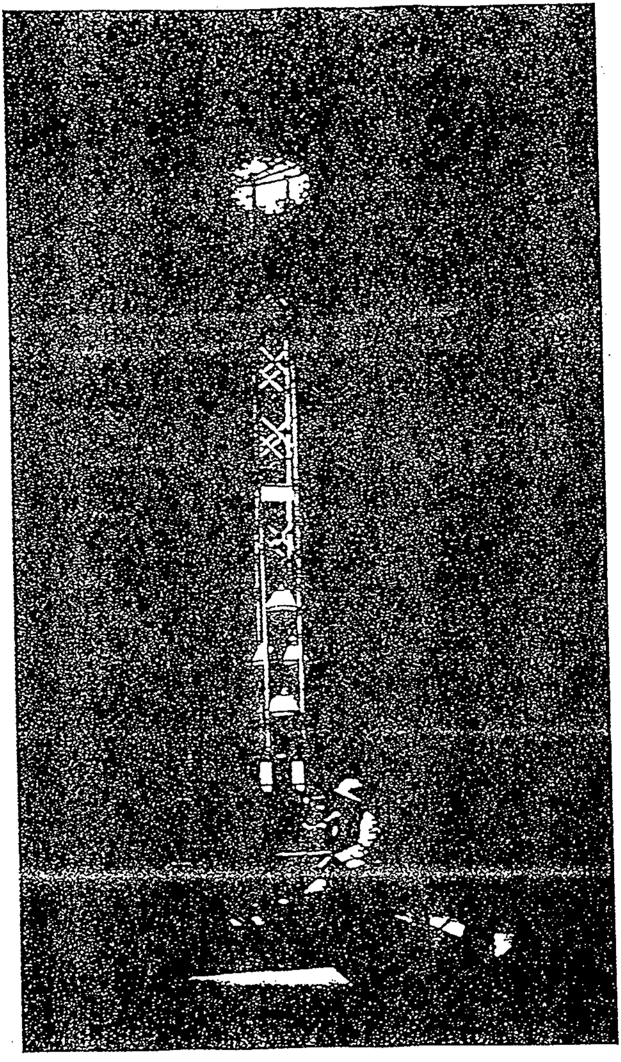
For the systems in SY-103, AW-101, and AN-103, 104 and 105, unless directed otherwise within the next 24 hours, I will have them de-energized and locked out. There is a safety concern with the inability to verify safety function integrity unless properly maintained.

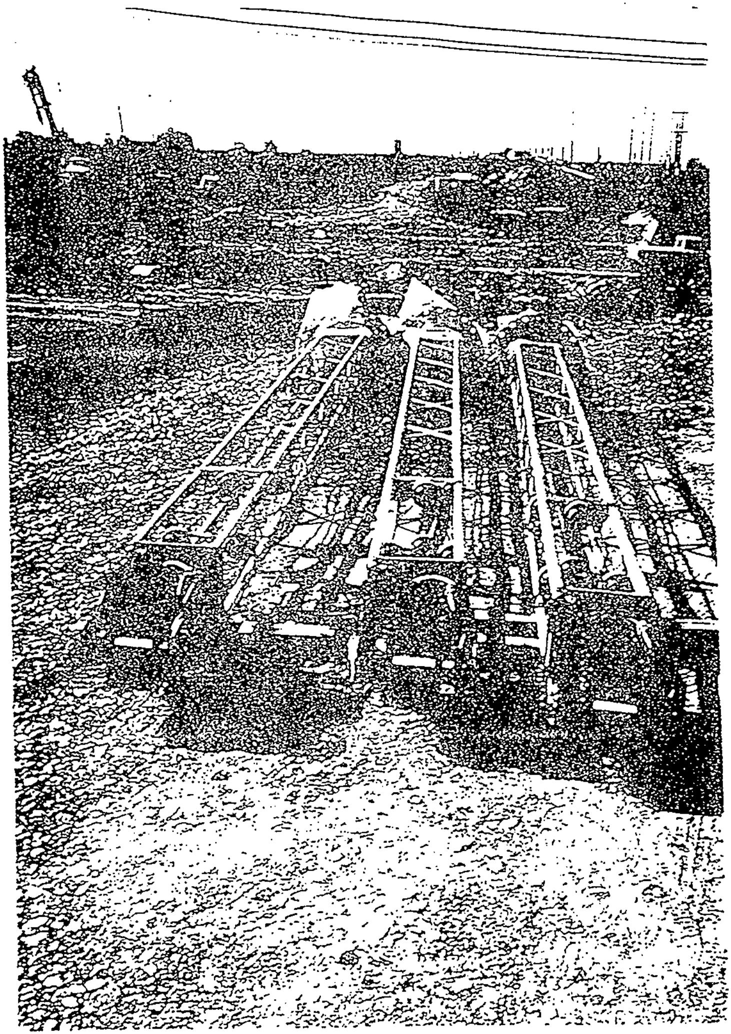
The impacts will be loss of the ability to gather valuable verification information when 'events' occur. The cost of maintaining the systems now that the maintenance and other procedures have been completed, isn't significant and is a dollar wash when compared to the costs of two to three incursions into these tanks with the portable systems (that aren't designed for the 'Big 6 environment), without taking ALARA and waste minimization into account.

Dave Smet

ATTACHMENT "C"

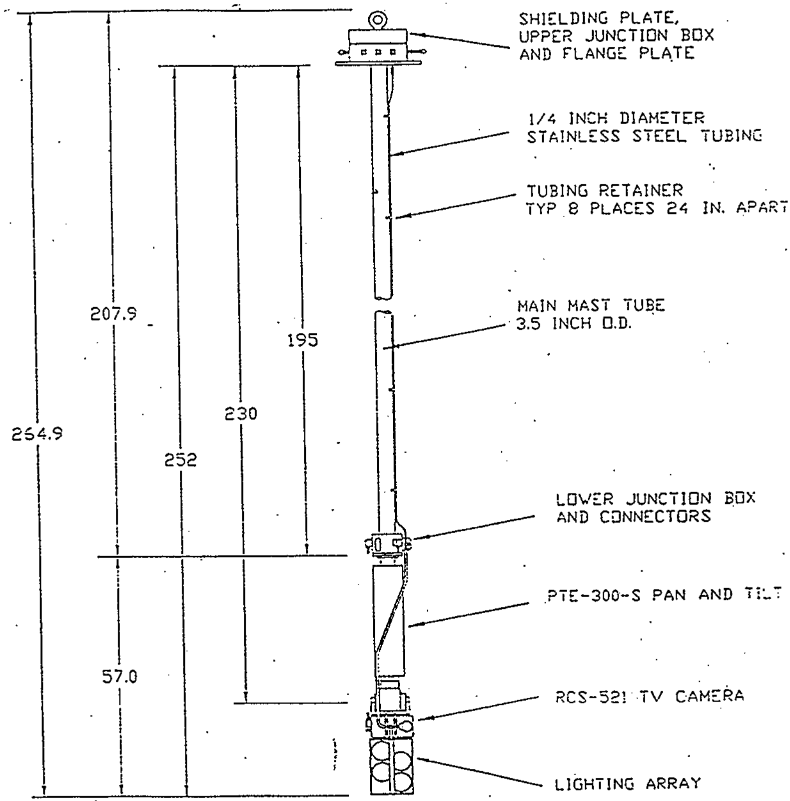






BEST AVAILABLE COPY

[illegible]



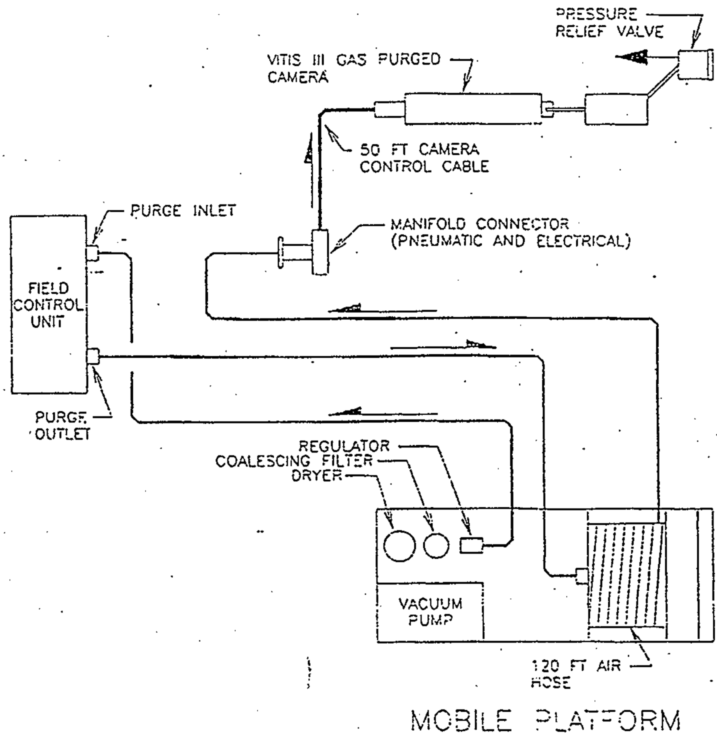
RADIATION TOLERANT WASTE TANK COLOR VIDEO
SYSTEM FOR WASTE TANK 241-C-106

ATTACHMENT "D"

06/29/95 10:12 ☎509 376 9191 SAMPLING OPS

[redacted]

FIGURE 3 - PURGE AIR ROUTING



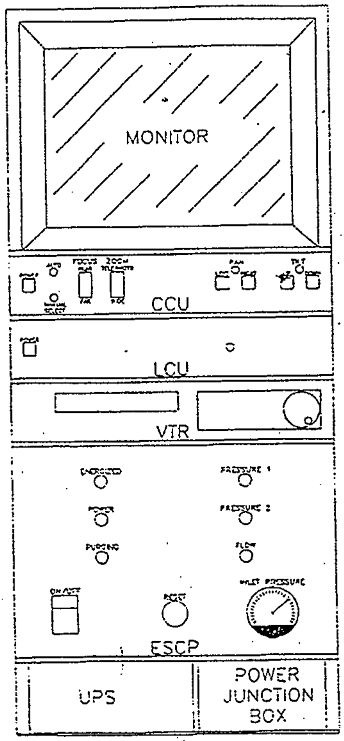
[redacted]

06/29/98 10:13 ☎509 376 8191 SAMPLING OPS. 002

[redacted] [redacted]

FIGURE 4 - MCCS CAMERA FIELD CONTROL UNIT

703 966 4016



[redacted] [redacted] [redacted] [redacted] [redacted]

F.5.1 241-AZ FARM VENTILATION THERMAL ANALYSIS MODEL RESULTS

Fluor Daniel Northwest	CALCULATION IDENTIFICATION AND INDEX	Page i of i Date 8/3/98

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline HVAC WO/Job No. Calculation No.

Project No. & Name

Calculation Item AZ-101 Waste Temperature During Transfer

These calculations apply to:

Dwg. No. Rev. No.

Dwg. No. Rev. No.

Other (Study, CDR) Study Rev. No.

The status of these calculations is:

[X] Preliminary Calculations

[] Final Calculations

[] Check Calculations (On Calculation Dated)

[] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [] Yes [X] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	Paul Rea 8/3/98		
Checked by	A. Z. Biscido 8/5/98		
Approved by			
Checked Against Approved Vendor Data			

INDEX

Design Analysis Page No.	Description
1	Objective, Given Data, Assumptions, References, Findings and Conclusions
2	Calculations
A-1, A-2	Appendix

A-6002-143 (01/97) GEF410

Fluor Daniel Northwest		Calc. No. Revision 0. Page No. 1 of 2
DESIGN ANALYSIS		
Client Numatec Hanford Corp	WO/Job No.	
Subject AZ-101 Waste Temperature During Transfer	Date 8/3/98	By P. D. Rice
	Checked 8/5/98	By A. Z. Brown
Location 200 E	Revised	By

1.0 OBJECTIVE

These calculations evaluate the adequacy of the ventilation system for tank AZ-101 of the aging waste tank farm during operation of mixer pumps totaling 600 hp. Operation of the mixer pumps will be only as needed to mobilize waste for transfer out of the tank.

2.0 GIVEN DATA

a) Waste to be transferred in 10 batches, one per month
b) Initial batch will be 500,000 l
c) Two 300-hp mixer pumps to operate 120 hrs prior to first transfer and for 18 hrs during transfer
d) Last batch will be mixed for 24 hrs prior to transfer and for 12 hrs during transfer
e) Waste characteristics per Ref. 1) and 4)

3.0 ASSUMPTIONS

a) Tank waste vapor suppression factor = 0.45
b) ALC flow rate = 0
c) Average summer OSA conditions = 77 °F @ 40% RH
d) Annulus airflow rate = 800 scfm
e) Radionuclide heat = 300,000 Btu/h (Ref. 2)

4.0 REFERENCES

1) Parameters for Use in CFD Simulations of the Mixing and Settling of Tank AZ-101, COGEMA-98-521, 6/24/98
2) Tank 241-AY and 241-AZ Waste Evaporation, Letter Report E62062 LR, ICF Kaiser Hanford Co., December 1995
3) Computer Code WTVFE, Y.J. Lee et al, 4/25/96
4) cc:mail, K. Sathyanarayana to P. D. Rice, 8/3/98

5.0 FINDINGS AND CONCLUSIONS

Operation of two 300 hp mixer pumps in tank AZ-101 prior to and during the first of ten waste transfers will raise the waste temperature from approximately 150 °F to 181 °F which is below the allowable operating temperature. During the last transfer, the waste temperature rise will be 2 °F per hour initially at full pump power. The existing ventilation system is adequate.

BD-6002-142 (02/97) GEF409

Fluor Daniel Northwest		Calc. No.
		Revision 0.
DESIGN ANALYSIS		Page No. 2 of 2
Client Numatec Hanford Corp	WO/Job No.	
Subject AZ-101 Waste Temperature During Transfer	Date 8/3/98	By P. D. Rice
	Checked 8/5/98	By C. Z. Bivens
Location 200 E	Revised	By

6.0 CALCULATIONS

6.1 Waste Temperature Prior to Mixing First Batch

Using the computer code of Ref. 3) with input from Ref. 2), the calculated initial temperature of the waste in AZ-101 before starting the mixing process for the first batch is 150 °F. This equilibrium condition corresponds to a tank ventilation flow of 500 scfm at a supply temperature of 77 °F and 40% RH. See attached computer calculation results. Operation of the ventilation system in the recirculation mode with minimal outside air flow of 100 scfm will give slightly lower temperature, based on recent field test data.

6.2 Waste Temperature Rise During Mixing, First Batch

Using the waste characteristics given in Ref. 1) and 4),

$$\Delta T = (600\ \text{hp})(2545\ \text{Btu/hp-hr}) / ((C_p = 0.75)(\text{Sp. Gr.} = 1.2)(900{,}000\ \text{gal})(8.3\ \text{lb/gal}))$$
$$= 0.227\ °\text{F/hr} = 5.5\ °\text{F/day}$$

∴ Total temperature rise over the mixing period of 138 hrs = (.227)(138) = 31 °F
∴ The temperature of the waste is expected to increase from 150 °F to 181 °F during the first batch transfer.

6.3 Waste Temperature Prior to Mixing Last Batch

Prior to transfer of the last of ten total batches, the radionuclide heat load should be approximately 10% of the current heat load, or approximately 30,000 Btu/h. Using the computer code of Ref. 3) with input from Ref. 2), the calculated initial equilibrium temperature of the waste before initiating mixing of the last batch is 88 °F. See attached computer calculation results.

6.4 Waste Temperature Rise During Mixing, Last Batch

Using the waste characterization given in Ref. 1),

$$\Delta T = (600\ \text{hp})(2545\ \text{Btu/hp-hr}) / ((C_p = 0.75)(\text{Sp. Gr.} = 1.2)(100{,}000\ \text{gal})(8.3\ \text{lb/gal}))$$
$$= 2.04\ °\text{F/hr} = 49\ °\text{F/day}$$

The rate of temperature rise will increase as the waste transfer proceeds, due to the continuous decline in waste mass. It is assumed that the pump power will be reduced as the transfer nears completion in order to avoid excessive waste temperature.

BD-6002-142 (02/97) GEF409

A-1

/ 101 AZ Initial Condition
Prior To First Transfer

Pump Heat = 0 Btu/h
Inlet Air Temp = 77 F
Suppression Factor = .45
ALC Flow Rate = 0 scfm
Tank Diameter = 75 ft
Tank Thickness = 1 in
Concrete Depth = 1.25 ft

Radionuclide Heat = 300000 Btu/h
Relative Humidity = 40 %
Inlet Air Temp at Annulus = 77 F
Annulus Flow Rate = 800 scfm
Tank Height = 35 ft Ann Gap = 30 in
Soil Depth = 10.5 ft
Outside Air Temp = 77 F

Soln Temp. F	Soln vp mm Hg	Annulus Loss Btu/h	Conduct Loss Btu/h	Net Evap lbH2O/h	Exit Hum Ra lbw/lbda	Required Flow scfm	Va Exit Cond F	/ %RH	Ann. Ex. Temp F
180.0	213.5	90065.	29407.	164.77	0.226	166.86	171.9	62.4	179.5
178.0	204.2	88304.	28846.	165.97	0.212	179.84	169.8	62.5	177.5
176.0	195.3	86544.	28285.	167.14	0.199	193.76	167.6	62.5	175.5
174.0	186.7	84784.	27723.	168.28	0.186	208.70	165.5	62.5	173.5
172.0	178.4	83023.	27160.	169.37	0.175	224.73	163.3	62.6	171.5
170.0	170.4	81263.	26596.	170.44	0.164	241.96	161.2	62.6	169.5
168.0	162.7	79503.	26031.	171.47	0.153	260.51	159.0	62.6	167.5
166.0	155.3	77743.	25465.	172.46	0.144	280.48	156.8	62.6	165.5
164.0	148.2	75982.	24898.	173.41	0.135	302.01	154.6	62.6	163.5
162.0	141.3	74222.	24330.	174.33	0.126	325.27	152.4	62.6	161.4
160.0	134.8	72461.	23761.	175.21	0.118	350.42	150.2	62.6	159.4
158.0	128.5	70701.	23192.	176.05	0.111	377.66	148.0	62.6	157.4
156.0	122.4	68941.	22621.	176.84	0.104	407.21	145.8	62.6	155.4
154.0	116.6	67181.	22049.	177.60	0.097	439.33	143.6	62.5	153.4
152.0	111.0	65420.	21476.	178.31	0.091	474.32	141.4	62.4	151.4
150.0	105.7	63660.	20902.	178.98	0.085	512.50	139.2	62.3	149.4
148.0	100.6	61900.	20327.	179.60	0.080	554.28	136.9	62.2	147.4
146.0	95.7	60140.	19751.	180.18	0.074	600.11	134.7	62.1	145.4
144.0	91.0	58379.	19174.	180.71	0.069	650.54	132.4	61.9	143.4
142.0	86.4	56619.	18596.	181.18	0.065	706.19	130.2	61.7	141.4
140.0	82.1	54859.	18017.	181.61	0.060	767.83	127.9	61.5	139.4
138.0	78.0	53099.	17437.	181.98	0.056	836.37	125.6	61.2	137.4
136.0	74.0	51339.	16855.	182.30	0.052	912.90	123.3	60.9	135.4
134.0	70.3	49579.	16273.	182.56	0.048	998.77	121.0	60.6	133.4
132.0	66.6	47819.	15689.	182.76	0.045	1095.65	118.8	60.1	131.4
130.0	63.2	46059.	15104.	182.89	0.041	1205.60	116.4	59.7	129.4
128.0	59.9	44300.	14518.	182.95	0.038	1331.24	114.1	59.1	127.4
126.0	56.7	42540.	13931.	182.94	0.035	1475.96	111.8	58.5	125.4
124.0	53.7	40781.	13342.	182.85	0.032	1644.14	109.5	57.9	123.4
122.0	50.9	39021.	12753.	182.67	0.030	1841.63	107.1	57.1	121.4
120.0	48.1	37262.	12161.	182.40	0.027	2076.37	104.8	56.3	119.4

```
'
' declare subroutine vappress
'
DECLARE SUB vappress (temp, vap)
'
'Description of the program
'
CLS
PRINT " "
PRINT " "
PRINT "This is a program to evaluate the required tank air flow rate and"
PRINT "outlet conditions from the radioactive waste storage tank."
PRINT "To run this program, be prepared to input the followings:"
PRINT "radiation decay heat, pump heat, tank air inlet temperature"
```

101 AZ Condition prior to Last Transfer A-2

```
Pump Heat =  0 Btu/h          Radionuclide Heat =  30000 Btu/h
Inlet Air Temp =  77 F        Relative Humidity =  40 %
Suppression Factor =  .45     Inlet Air Temp at Annulus =  77 F
ALC Flow Rate =  0 scfm       Annulus Flow Rate =  800 scfm
Tank Diameter =  75 ft        Tank Height =  4 ft          Ann Gap =  30 in
Tank Thickness =  1 in        Soil Depth =  10.5 ft
Concrete Depth =  1.25 ft     Outside Air Temp =  77 F
```

Soln Temp. F	Soln vp mm Hg	Annulus Loss Btu/h	Conduct Loss Btu/h	Net Evap lbH2O/h	Exit Hum Ra lbw/lbda	Required Flow scfm	Va Exit Cond F	/ %RH	Ann. Ex. Temp F
100.0	27.0	13643.	8723.	5.51	0.023	81.79	98.3	57.3	92.5
98.0	25.4	12286.	8176.	6.85	0.021	114.06	96.3	56.9	91.0
96.0	23.9	10945.	7629.	8.18	0.020	153.77	94.2	56.3	89.5
94.0	22.5	9622.	7083.	9.50	0.018	203.38	92.2	55.8	87.9
92.0	21.1	8320.	6538.	10.82	0.017	266.63	90.2	55.1	86.5
90.0	19.8	7041.	5996.	12.14	0.016	349.38	88.2	54.3	85.0
88.0	18.6	5790.	5459.	13.49	0.014	461.42	86.2	53.4	83.6
86.0	17.5	4572.	4928.	14.87	0.013	620.33	84.2	52.3	82.2
84.0	16.4	3396.	4407.	16.33	0.012	861.03	82.4	51.0	80.9
82.0	15.4	2274.	3906.	17.89	0.011	1262.67	80.6	49.3	79.6
80.0	14.4	1230.	3439.	19.53	0.010	2039.66	79.2	47.1	78.4
78.0	13.5	324.	2910.	24.03	0.009	6060.44	77.2	44.1	77.4

```
Waste temperature is too high. Will try next temperature step(B).
Waste temperature is too high. Will try next temperature step(B).
Waste temperature is too high. Will try next temperature step(B).
Waste temperature is too high. Will try next temperature step(B).
Waste temperature is too high. Will try next temperature step(B).

Annulus air inlet temperature is higher than waste temperature.
Annulus heat transfer is ignored.
Also, convergence problem exits for air flow rate
'
'  declare subroutine vappress
'
DECLARE SUB vappress (temp, vap)
'
'Description of the program
'
CLS
PRINT " "
PRINT " "
PRINT "This is a program to evaluate the required tank air flow rate and"
PRINT "outlet conditions from the radioactive waste storage tank."
PRINT "To run this program, be prepared to input the followings:"
PRINT "radiation decay heat, pump heat, tank air inlet temperature"
PRINT "and relative humidity, air flowrate and temperature in the annulus,"
PRINT "and the air lift circulation flowrate. Also, vapor suppression"
PRINT "fraction for the waste in the tank, tank dimensions and desired"
PRINT "waste temperature range to be considered and tank dimensions."
PRINT " "
PRINT "If you make a mistake duing the input phase, you can terminate"
PRINT "the program by typing Ctrl-Break anytime and restart"
PRINT " "
```