U.S. Department of Energy
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JAN 1 2 2012

12-WTP-0020

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004-2901

TRANSMITTAL OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) RECOMMENDATION 2010-2 IMPLEMENTATION PLAN DELIVERABLE 5.7.3.4

Dear Mr. Chairman:

This letter provides you the deliverable responsive to Commitment 5.7.3.4 of the U. S. Department of Energy (DOE) Plan to Address Waste Treatment and Immobilization Plant (WTP) Vessel Mixing Issues; Implementation Plan (IP) for Defense Nuclear Facilities Safety Board Recommendation 2010-2.

The attached report identifies key inputs, assumptions, safety margin uncertainties, and nuclear safety parameters required to be included in the Waste Acceptance Criteria (WAC) for waste delivered from the Hanford tank farms to the WTP. The information in this report also provides input to the IP deliverables for Commitments 5.5.3.1, *Initial gap analysis between WTP WAC and tank farm sampling and transfer capability*, and 5.7.3.1, *Establish the plan and schedule to systematically evaluate the hazards of know technical issue, M3 vessel assessment summary report, LOAM benchmark data, and LSIT results.* Deliverables for Commitments 5.5.3.1 and 5.7.3.1 will be provided to the DNFSB later this year per the IP.

The WAC for the WTP will continue to evolve based on assessments focused on WTP vessel mixing, transfer, and sampling system performance and be informed by Tank Farm feed staging, sampling, and transfer capabilities. The resulting information will be evaluated consistent with section 5.7.2, *Resolution Approach,* of the IP. We will keep the DNFSB informed of progress and identified issues as work progresses via Quarterly reports and subsequent IP deliverables.

If you have any questions, please contact me at (509)376-6727 or your staff may contact Ben Harp, WTP Start-up and Commissioning Integration Manager at (509)376-1462.

Dale E. Knutson, Federal Project Director
Waste Treatment and Immobilization Plant

WTP:RAG

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History Sheet

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Contents

Appendices

Tables

Acronyms

ALARA	As Low As Reasonably Achievable
BOD	Basis of Design
CSER	Criticality Safety Evaluation Report
DNFSB	Defense Nuclear Facility Safety Board
DOE	US Department of Energy
DQO	data quality objective
DSA	documented safety analysis
EFRT	External Flowsheet Review Team
FRP	feed receipt process
HLP	HLW lag and feed blending process system
HLW	High-Level Waste Facility
ISARD	Integrated Sampling and Analysis Requirements Document
LAW	Low-Activity Waste Facility
PDSA	preliminary documented safety analysis
PIER	Project Issues Evaluation Reporting
PJM	pulse jet mixer
PTF	Pretreatment Facility
SAC	specific administrative control
TSR	technical safety requirement
ULD	unit liter dose
WAC	waste acceptance criteria
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1 Introduction

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) is being constructed to complete the cleanup of the waste, which is currently stored in underground tanks, that resulted from over 40 years of reactor operations and plutonium production for national defense.

The Defense Nuclear Facilities Safety Board (DNFSB) expressed concerns related to WTP's mixing and transfer systems. The DNFSB issued Recommendation 2010-2, *Pulse Jet Mixing at the Waste Treatment and Immobilization Plant* in December of 2010. The recommendation addressed the need for the U.S. Department of Energy (DOE) to ensure that the WTP, in conjunction with the Hanford tank farm waste feed delivery system, will operate safely and effectively during the 40-year operating life to eliminate the risks posed by the high-level waste in the Hanford tank farm. The safety issues relevant to DNFSB's concerns about the pulse jet mixing and transfer systems are identified in Recommendation 2010-2 as:

1. Accumulation of fissile material at the bottom of vessels leading to potential criticality;
2. Generation and accumulation of hydrogen resulting from the accumulation of solids; and
3. The possibility that accumulating solids will interfere with the vessel-level detection system leading to loss of pulse jet mixer (PJM) control and overblows (discharge of air from the PJM).

The DOE issued an implementation plan for DNFSB Recommendation 2010-2 on November 10, 2011 (Reference 6.1). The response to Sub-Recommendation 7, Technical and Safety-Related Risks, in that implementation plan contained several milestone commitments. This report provides the response to Commitment 5.7.3.4 in that document.

2 Commitment 5.7.3.4

Sub-Recommendation 7, Commitment 5.7.3.4 states:

> *Identify key inputs, assumptions, safety margin uncertainties, and nuclear safety parameters required to be included in the waste acceptance criteria.*

The deliverable must consist of:

> *Report documenting the current nuclear safety parameters that must be included in the WAC. The report will identify the analytical capabilities required to identify waste that exceeds the WAC. If there are changes to the current WAC established in ICD-19, the deliverable will also include the required changes to the ICD.*

The implementation plan for DNFSB Recommendation 2010-2 (Reference 6.1) provides additional discussion on this commitment as follows:

> *These parameters will be based on inputs and assumptions to the current hazards and accident analyses (e.g., unit liter dose), inputs and assumptions from engineering documents providing the technical basis for the performance of mixing, transport, and sampling structures, systems, and components, and an updated CSER.*

The information in this report will provide input to DNFSB Recommendation 2010-2 IP Commitments 5.5.3.1, *Initial gap analysis between WTP WAC and tank farm sampling and transfer capability* and Commitment 5.7.3.1, *Establish the plan and schedule to systematically evaluate the hazards of known technical issues, M3 vessel assessment summary reports, LOAM benchmark data, and LSIT results.*

3 Approach

The exact contents of the underground tanks at the Hanford site are not known and have been estimated based on available sampling data and review of process records and history. The purpose of the WTP Preliminary Documented Safety Analysis (PDSA) is to document the nuclear safety design criteria and the hazards expected with the activities that will be performed at the WTP, to develop a safety analysis that derives aspects of the design necessary to satisfy the nuclear safety design criteria and to identify controls necessary to ensure that the facility, once constructed, can be operated safely with respect to the workers, the public, and the environment.

A final Documented Safety Analysis (DSA) based on the final design must be prepared and approved by DOE prior to commencing operation. A Specific Administrative Control (SAC) will be established to ensure compliance with the Waste Acceptance Criteria (WAC) to provide assurance that the Pretreatment Facility will be operated within the defined safety envelope. The parameters that must be monitored to ensure compliance with the safety basis are those specifically identified in the safety analysis.

This report identifies the sources of the data that have contributed to the information currently in the WAC as well as those parameters that are of particular importance to the safety analysis in the Pretreatment Facility (PTF). Those parameters related to sampling required for safe operation of the PTF downstream of the receipt vessels are addressed in the response to Commitment 5.7.3.1, Establish the plan and schedule to systematically evaluate the hazards of known technical issues, M3 vessel assessment summary reports, LOAM benchmark data, and LSIT results. The resolution of known technical issues that may emerge from the closure of other DOE commitments in the implementation plan (e.g., result of gap analyses completed in response to Commitments 5.5.3.1, Initial gap analysis between WTP WAC and tank farm sampling and transfer capability, and 5.5.3.3, Update the WAC based on LSIT results) will be processed and tracked to closure under Commitment 5.7.3.1.

4 Response to Commitment 5.7.3.4

4.1 Key Inputs

The waste acceptance criteria is summarized in ICD-19, *Interface Control Document for Waste Feed* (Reference 6.2). Key input documents specifying the parameters that contribute to the WAC include the WTP Contract (Reference 6.3), the PDSAs (References 6.4 through 6.9), the PDSA Addenda (Reference 6.10), and the Criticality Safety Evaluation Report (CSER) (Reference 6.11). The Basis of Design (BOD) (Reference 6.13) also specifies criteria for inclusion in the WAC. The Integrated Sampling and Analysis Requirements Document (ISARD) (Reference 6.14), which identifies the sampling and analysis requirements to be performed to control plan processes, monitor the release of effluents, and verify that WTP products comply with established requirements, and the data quality objectives (DQO) for WTP feed acceptance criteria (Reference 6.15), which details the activities associated with the initial development of DQO requirements to meet WAC for transfer of staged feed from tank farms to the WTP, are also key documents but not inputs to the waste acceptance criteria. Copies of the applicable pages of the WTP Contract, in particular Specification 7, *Low-Activity Waste Envelopes Definitions*, and Specification 8, *High-Level Waste Envelope Definition*, are included in Appendix A and Appendix B, respectively. The applicable pages from ICD-19 are included in Appendix C. The information presented in these appendices was taken from the existing documents and is provided for convenience. The key input documents are living documents and are subject to change. Engineering assessments performed by BNI to address technical issues including External Flowsheet Review Team (EFRT) mixing issues (M3) have made assumptions that may result in updated WAC requirements.

4.2 Assumptions

The process of developing calculations and supporting analyses involves the use of assumptions. However, not all assumptions must be protected at the level of a technical safety requirement (TSR). Assumptions key to the establishment of the safety envelope are protected as TSR level controls. This report discusses those assumptions associated with the WAC that are currently planned to be protected as TSR level controls. Assumptions that have potential to become WAC requirements are also discussed.

4.2.1 Current Nuclear Safety Assumptions

Establishing the safety envelope begins with evaluating the types and quantities of material that will be present in the facility. The approach used in the safety analysis involves converting the expected waste feed material to a Unit Liter Dose (ULD) based on available tank waste information and projections of feed that may be delivered to WTP. This information is used as the basis for determining the dose consequences for postulated events. Consequently, this assumption will be protected as a TSR level control. The plutonium to metals loading ratio and the fissile uranium to total uranium ratio for the waste solids phase are assumed in the evaluation of the potential for criticality and are currently identified as having been selected as requiring protection as TSR level controls as discussed in the PDSA. Per the above discussion, the following assumptions are currently identified in the analyses supporting the PDSA and will be protected at the TSR level:

1. The public receptor specific dose factor for the solids in the waste feed is 270 Sv per gram (dry basis). (Reference 6.10). This requirement is specific to high-level waste (HLW) waste feed material.
2. The public receptor specific dose factor for the liquid in the waste feed is 1,500 Sv per liter and a maximum sodium molarity of 10 (Reference 6.10). This requirement is specific to low-activity waste (LAW) waste feed material.
3. The plutonium to metal loading ratio and the fissile uranium to total uranium loading ratio for the waste solids phase are confirmed within safe limits before waste enters WTP (References 6.4 and 6.11). The CSER has an outstanding condition of acceptance directing that TSR level controls should not be established for the plutonium concentration and plutonium to metal loading ratio for the liquid phase (Reference 6.12).

These parameters are identified as waste acceptance criteria parameters in ICD-19 (Reference 6.2).

4.2.2 Engineering Design Parameters and Assumptions

Engineering assessments to address mixing issues include assumptions that may result in updated WAC requirements. The vessel mixing performance assessments (References 6.22 and 6.23) identify the following design basis properties that may require protection at the TSR level during the development of the DSA.

1. Solids concentration in the FRP-02 vessels will range between 0 and 3.8 wt% as delivered solids based on 5 M sodium supernate.
2. Sodium content in the FRP-02 vessels will be 4 to 10 M.
3. Solids density in the FRP-02 vessels will be variable equivalent to 0.03 ft/min settling rate.
4. The viscosity in the FRP-02 vessels will range from 1.1 cP to 26 cP.
5. The slurry density in the FRP-02 vessels will range from 1.1 g/ml to 1.6 g/ml.
6. The temperature range in the FRP-02 vessels will be between 59 °F and 120 °F.
7. The solids concentration in the HLP-22 vessel will vary linearly from 10 grams unwashed solids/liter to a maximum of 107 grams of unwashed solids/liter at 0.1 M Na to 144 grams/liter at 7 M Na.
8. The sodium content in the HLP-22 vessel will range between 0.1 and 7 M.
9. Solids density in the HLP-22 vessel will be limited to 2.9 g/ml.
10. Particle size in the HLP-22 vessel ranges from 0.7 to 700 μm.
11. Viscosity in the HLP-22 vessel ranges from 1 to 50 cP.
12. Slurry density in the HLP-22 vessel ranges from 1.0 to 1.7 g/ml.
13. The maximum temperature in the HLP-22 vessel is < 150 °F.
14. An average upper bound settled layer shear strength of up to 200 Pa can be expected within 24 hours. The 200 Pa will serve as a basis as the shear strength limit for the full scaled vessel.
15. The bounding PuO_2 particle is 10 μm.

Final evaluation of these parameters will occur during the development of the DSA.

4.3 Safety Margin Uncertainties

The identification of safety margin uncertainties for the waste acceptance criteria is included in Sub-Recommendation 7, Commitment 5.7.3.4. The safety margin is directly related to the values specified in the TSRs, which have not yet been developed. In addition, the hazards analysis and accident analyses required to provide the basis for the TSRs have not been finalized. As the control strategy for Pretreatment is developed, Bechtel National, Inc. will identify samples required for safety (i.e., specifically credited in the accident analysis) along with any uncertainties that need to be addressed. The balance of this section provides an overview of how safety margin uncertainties with sampling and analysis will be resolved.

The three sources of interest for uncertainties are the uncertainties in the Engineering analyses, the ability to obtain a representative sample from the waste and the measurement uncertainties associated with the sample analyses.

The uncertainties in the Engineering analyses will be taken into account as part of the determination of the TSR limits when the TSRs are developed. The ability to obtain a representative sample is associated with the feed qualification process. The evaluation of that process may also have an impact on the TSR limits that are established. The uncertainties with these two source contribute to the safety margin uncertainty. The uncertainties associated with the sample analyses will be taken into account when comparing measured values against the TSR limits, to ensure that the measured value plus the overall uncertainty remains within the TSR limits, and will contribute to the establishment of operational limits.

The waste acceptance criteria that are necessary to protect the safety basis will be established as a SAC in the TSRs. The TSRs will be written during the development of the DSA and will be supported by Engineering Analyses. Those Engineering analyses have not been fully developed. Once developed, quantifiable uncertainties can be identified but in some cases the uncertainties are addressed through the use of conservative bounding assumptions that are not quantifiable. Until these analyses are completed, the uncertainties in the safety margin associated with the Engineering analyses cannot be provided.

The capability to obtain adequately representative samples is addressed in Sub-Recommendation 5, Representative Samples from Waste Feed Tanks. As previously discussed, the uncertainties associated with the sampling methodologies that are established may also affect the TSRs and corresponding waste acceptance criteria.

Based on expected changes in some of the waste acceptance criteria due to known issues with the analytical capabilities needed to meet those criteria, the sampling plan that will ultimately be needed to ensure compliance with the WAC has not been defined. Consequently, the uncertainties associated with the sampling analyses that will be used are not currently known. This item is a known technical issue and will be tracked to closure under Commitment 5.7.3.1.

4.4 Nuclear Safety Parameters

Many of the parameters in the WAC are associated with the ability to produce an acceptable vitrified product. While these parameters are important to the production system from a project mission perspective, they do not all have an impact on nuclear safety. The goal of nuclear safety is to ensure that the risk associated with the process is within acceptable limits with respect to the worker, the public and the environment. Parameters that are associated with hydrogen control and criticality, such as those affecting mixing, sampling, and transport, have been established as parameters being important to nuclear safety. The ongoing hazards analyses have identified other potential parameters that may be elevated to the level of the TSRs. The following sections identify the nuclear safety parameters, with respect to the WAC, that have already been established as well as potential additional requirements that may be imposed as the design matures and as the results of testing are received.

4.4.1 Current Nuclear Safety Parameters

The assumptions identified in Section 4.2 must be protected as TSR level controls. Several TSR level controls associated with waste stream sampling requirements for transfers into and out of the facilities have been identified but not fully developed. The requirement to sample the waste prior to transfer to ensure it meets acceptance criteria has been established but the specific parameters and limits have not yet been identified in the PDSA. This information must be finalized when the DSA is developed. The existing controls with specifically identified parameters are included in this section. In addition to those parameters described in Section 4.2, the following nuclear safety parameters are currently identified as limiting requirements:

1. As described in the PTF PDSA (Reference 6.5), Section 5.5.22.1, Administrative Controls - Source Inventory Receipt Acceptance Program. The hazard and accident analysis, criticality safety analysis, and HPAV controls assume that the source inventories received at the PTF are within specification before the feed is processed further. This administrative control requires a program to be developed to protect this assumption. In addition, the LAW and HLW facilities rely upon the PTF to ensure that their source inventories are within specifications. Thus, this administrative control protects the TSR interfaces with the LAW and HLW facilities, as well. Key elements of this program include:
   - The waste feed receipt vessels (FRP-VSL-00002A/B/C/D) are prohibited from receiving waste containing solids ≥ 5 weight percent.
   - A source term receipt acceptance program shall be established, implemented, and maintained to ensure that the WTP accepts only hazardous and radiological waste authorized in the WTP DSA.
   - Acceptance criteria is established to ensure that radiological and hazardous material inventories in waste streams received by the WTP are limited to those source term values analyzed in the WTP DSA.
   - Procedures will be established to ensure that waste receipt transfers meet WTP waste receipt acceptance criteria.
   - Recordkeeping requirements will be established to ensure that records are maintained and available for review, and to document that waste material received into the WTP meets the waste receipt acceptance criteria.
   - Each batch of waste received from the tank farm shall be sampled to measure median particle hardness concentration and particle size distribution prior to acceptance for processing in the facility. Waste particle characterization for the waste batch shall be bounded by the WTP design basis (Reference 6.17). Waste batches that exceed the WTP design basis particulate characteristics must be evaluated for adequate safety, and a basis for processing of the waste determined, and approved by ORP, prior to acceptance of the waste.
   - Specific provisions of the waste acceptance program shall be instituted to ensure waste hydrogen generation rates and dissolved ammonia concentrations are within allowable limits. The provisions shall include increases in purge air flows of vessels receiving tank farm feeds and confirmatory sampling of received waste.

2. The PJM and sparger operations discussed in the hydrogen explosion DBE for vessels (Section 3.4.1.8) [of the Pretreatment Facility PDSA] are based on Research and Technology testing. The testing program demonstrated using simulants, based on tank waste data, that the combination of PJMs and spargers can mix and release retained hydrogen from non-Newtonian waste up to 30 Pa/30 cP. Therefore, a waste rheology limit for the pretreated waste of a maximum 30 Pa and 30 cP, is required to ensure mixing and hydrogen release. This requirement is identified in the PTF PDSA (Reference 6.5), Section 5.5.22.17, Administrative Controls - Waste Rheology for Mixing. Key elements of this program include:

- Using tank farm grab samples, measure waste rheology prior to transferring to the PTF (waste feed receipt process system [FRP] vessels, the HLW lag and feed blending process system [HLP] vessels). If the waste rheology of samples exceeds the WTP waste limit to ensure mixing and hydrogen release (30 Pa/30 cP maximum) and cannot be blended with other waste streams to reach an acceptable rheology, the samples will not be processed further in the WTP and will be returned to the tank farm.
- Use the results of the Contract Specification 12 analyses (for washing and leaching) to determine if washing and leaching will result in waste rheology exceeding the WTP limit (30 Pa/30 cP). If the rheology limit is exceeded and cannot be met by blending with other waste streams, the waste should not be processed further, but should be returned to the tank farm.

The Integrated Sampling and Analysis Requirements Document (Reference 6.14), Appendix B, Analytical Data Objectives, states that the waste feed receipt vessels receive tank farm waste and transfer waste for processing within pretreatment. Flowsheet operating parameters must be verified based on characteristics of received waste. For solids content, the action limit is 3.8 wt% solids. ICD-19 specifies that the LAW transfer solids concentration must be ≤3.8 wt% solids measured after holding the sample at 25 °C for 8 hours. The M3 PJM Vessel Mixing Assessment (Reference 6.18) evaluated 3.8 weight percent solids in the four FRP vessels. These values are consistent with each other and with the requirements in Specification 7 of the contract (Reference 6.3) but this information has not yet been incorporated into the PDSA, which currently states that waste feed with ≥5 weight percent solids are prohibited from being transferred to these vessels, and is a known issue being tracked by PIER item 24590-WTP-PIER-MGT-12-0021 (Reference 6.19). Solids will be delivered to the WTP after there has been sufficient settling time to ensure solids that settle faster than 0.03 ft/min have settled below the transfer location within the tank farms staging tank (Reference 6.2). As development of the final DSA and CSER are completed, additional limitations may be established.

One of the requirements above includes mean particle size and particle distribution. Mean particle size is included in ICD-19 but particle size distribution is not. A change to this requirement to use abrasivity in lieu of particle size is being investigated, but has not yet been incorporated into the PDSA. This is currently an open item identified in ICD-19. The particle size distribution should also be specified as particle size distribution assuming a given spherical particle density. This information is expected to be refined as the design and associated analyses progress.

A waste rheology limit of 30 Pa and 30 cP is identified in the PDSA. The 30 Pa/30 cP limit applies to the material in the five non-Newtonian vessels. Confirmation that the waste slurry will conform to the 30 Pa/30 cP criteria is anticipated to be based on feed prequalification work to assess rheology following washing and leaching in the Pretreatment ultrafiltration system.

The < 1 Pa and < 10 cP WAC limit in ICD-19 must be measured prior to transferring to the PTF to ensure the feed meets this criteria. The <1 Pa and <10 cP WAC limits in ICD-19 include a note indicating that these values are used in the WTP design but still under investigation as needed or applicable for waste feed acceptance.

4.4.2 Potential New Nuclear Safety Parameters

The ability to mix the contents of the vessels is a primary concern at the WTP because mixing is relied on as part of the methodology to control hydrogen accumulation. Maintaining vessel content rheology is one important aspect because the viscosity and solids concentration of the contents can change based on a number of different parameters such as temperature and pH. The receipt vessels in the PTF have established limits regarding the types of material that can be accepted because the ability to control hydrogen retention is based in part on the ability to mix the contents of the vessels. The use of PJMs provides one aspect of mixing in the vessels. The results of the ongoing studies as part of LSIT will determine the mixing capabilities of the PJMs. Once this testing is complete, additional waste acceptance criteria may be identified.

WTP has obtained additional information addressing the CSER open item associated with the potential for non co-precipitated large fissile particles being present in waste in amounts greater than originally projected (References 6.20 and 6.21). The process to evaluate the impacts of this information on criticality safety controls and the WAC/ICD-19 requirements is just beginning. Thus any changes or additions to the WAC/ICD-19 related to this information will be included in later revisions, once the criticality evaluation process is complete.

With the possibility of adding additional materials to the existing tanks (e.g., encapsulated material such as cesium chloride/strontium fluoride capsules produced at B Plant at Hanford), ALARA considerations related to annual worker exposures require establishing an upper limit for the Cs-137/Ba-137m concentration in waste to ensure shielding is adequate to limit exposures.

The response to Commitment 5.7.3.1 in the implementation plan (Reference 6.1) addresses known technical issues. The resolutions to these issues may have the potential to affect the waste acceptance criteria. Additionally, a review of the reports associated with the M3 PJM vessel mixing assessments for the PTF receipt tanks for LAW and HLW (References 6.22 and 6.23) were reviewed to determine if requirements associated with waste acceptance criteria were identified.

While specific values have not yet been established in all cases, the following WAC parameters are potential future candidates for inclusion in the list of nuclear safety parameters that may be identified as waste acceptance criteria:

1. LAW feed slurry pH must be ≥ 12 (Reference 6.2).
2. LAW solids concentration must be ≤ 3.8 wt% based on 5 M sodium supernate. The solids are measured after holding the sample at 25 °C for 8 hours (Reference 6.23).
3. LAW slurry bulk density ρ_{Mb} must be < 1.46 kg/L (Reference 6.2).
4. LAW feed temperature must be ≥ 59 °F (Reference 6.23).
5. LAW feed temperature must be < 120 °F (Reference 6.23).
6. LAW allowable viscosity range of 1.1 cP to 26 cP (Reference 6.23).
7. LAW feed hydrogen generation rate ≤ 3.7E-07 gmole H_2/L/Hr @ 120 °F (Reference 6.2).
8. HLW transfer solids concentration must be ≤ 200 g/L measured after holding sample at 25 °C for 8 hours (Reference 6.2).
9. HLW solids concentration of 10 grams unwashed solids/liter to a maximum of 107 g/L at 0.1 M Na to 144 g/L at 7M Na (Reference 6.22).
10. HLW sodium content must be 0.1 to 7 M (Reference 6.22).

11. HLW slurry pH must be ≥ 12 (Reference 6.2).
12. HLW slurry density must be between 1 and 1.7 g/ml (Reference 6.22).
13. HLW feed temperature must be ≥ 59 °F (Reference 6.22).
14. HLW feed temperature must be < 150 °F (Reference 6.22).
15. HLW feed particle size ≤ 700 μm (Reference 6.22)
16. HLW feed hydrogen generation rate ≤ 2.1E-06 gmole H_2/L/Hr @ 150 °F (Reference 6.22).
17. Ammonia < 0.04M (Reference 6.14).
18. An average upper bound settled layer shear strength of up to 200 Pa can be expected within 24 hours. The 200 Pa will serve as a basis as the shear strength limit for the full scaled vessel (Reference 6.22).
19. The bounding PuO_2 particle is 10 μm spherical equivalent diameter in HLP-22 (Reference 6.22).
20. Average particle density of 2.9 for pre-leached solids and 3.8 for post leached solids (References 6.22 and 6.24).
21. Thermal conductivity of the sludge is >0.6 W/m K (Reference 6.25).
22. The specific heat capacity of the sludge is > 2.4 kJ/kg °C (Reference 6.25).
23. The settled non-convective layer in a vessel is 10% by volume (Reference 6.5).
24. The heat capacity for the non-convective layer is 2,850 J/(kg-K) (Reference 6.5).

Different particle sizes are included in the list. Each of these values is associated with a different waste consideration. Per the BOD (Reference 6.13), for the HLW feed, the maximum design basis particle size for tank farm transfers to WTP is 700 μm at a solids density of 2.9 g/ml. The BOD also specifies that the maximum PuO_2 particle size to be considered in design is 10 μm. The 11 μm particle size value specified in ICD-19, and shown in Table 1, represents the 95% confidence upper limit median particle size for use in conjunction with specified hardness values for erosion/corrosion evaluations as specified in 24590-WTP-RPT-M-05-001 (Reference 6.17).

Several of these parameters are already included in ICD-19. The final determination as to which parameters must be protected as TSR controls will be established once the hazards and accident analyses have been completed. Additional controls beyond those already identified or proposed may be required following the identification of hazards or as a result of LSIT and following the revision of the accident analyses. If different parameters are identified during the development of the DSA, the waste acceptance criteria will be updated, as necessary, to reflect those changes.

4.5 Analytical Capabilities

The WTP is designed to treat waste envelopes within the limits identified in Specification 7, *Low-Activity Waste Envelopes Definitions*, and Specification 8, *High-Level Waste Envelope Definitions*, in the WTP Contract (Reference 6.3). Reference 6.2 (ICD-19) identifies criteria for LAW feed, HLW feed, and general feed and is the contractual source of the waste acceptance criteria. Compliance with these parameters is necessary to ensure that the vitrified product will meet the established standards and provide assurance that the facility can operate within the established safety basis. The laboratories that perform the analyses must have the capabilities to analyze samples to the required criteria. The required accuracies associated with the measurements of the parameters applicable to nuclear safety will be dependent upon the uncertainties in the supporting calculations developed to support the TSRs. Sampling methods must be able to collect correct, representative samples, within acceptable sampling errors as well.

Analytical capabilities are needed to demonstrate compliance with the existing nuclear safety parameters identified in Sections 4.2 and 4.4.1 are as follows:

- The ability to ensure that the public receptor dose for solids is less than 270 Sv/g (dry basis).
- The ability to ensure that the public receptor dose for liquids is less than 1,500 Sv/L at a Na molarity of 10.
- The ability to ensure that plutonium to metal loading and fissile uranium to total uranium loading are confirmed within safe limits to ensure criticality safety.
- The ability to measure median particle harness concentration and particle size distribution to control erosion and corrosion.
- The ability to determine that the waste rheology is a maximum 30 Pa and 30 cP to ensure adequate mixing and transport to limit hydrogen accumulation.
- The ability to determine that the waste feed destined for the PTF FRP vessels does not contain greater than or equal to 5 weight percent solids to ensure adequate mixing and transport to limit hydrogen accumulation.

If additional criteria are identified during the development of the DSA, the analytical capabilities needed to demonstrate compliance with those criteria must be establish and the determination regarding the ability to implement the controls must be made. For the potential new parameters identified in Section 4.4.2, the analytical capabilities needed for those value would be:

- The ability to determine that the LAW feed slurry pH is $\geq$ 12.
- The ability to determine that the LAW solids concentration is $\leq$ 3.8 wt% based on 5 M sodium supernate.
- The ability to determine that the LAW slurry bulk density ρMb is < 1.46 kg/L.
- The ability to determine that the LAW feed temperature is $\geq$ 59 °F and < 120 °F.
- The ability to determine that the LAW feed viscosity is between 1.1 cP and 26 cP.
- The ability to determine that the hydrogen generation rate of the LAW feed is $\leq$ 3.7E-07 gmole H2/L/Hr @ 120 °F.
- The ability to determine that HLW transfer solids concentration is $\leq$ 200 g/liter.
- The ability to determine that the HLW solids concentration is 10 grams unwashed solids/liter to a maximum of 107 g/L at 0.1 M Na to 144 g/L at 7M Na.
- The ability to determine that the HLW sodium content is between 0.1 and 7 M.
- The ability to determine that the HLW slurry pH is $\geq$ 12.
- The ability to determine that the HLW slurry density is between 1 and 1.7 g/ml.
- The ability to determine that the HLW feed temperature is $\geq$ 59 °F and < 150 °F.

- The ability to determine that the HLW feed particle size ≤ 700 microns.
- The ability to determine that hydrogen generation rate of the HLW feed is ≤ 2.1E-06 gmole H2/L/Hr @ 150 °F.
- The ability to determine that the ammonia content of the feed is < 0.04M.
- The ability to determine that the shear strength of the settled layer after 24 hours is less than 200 Pa.
- The ability to determine that the bounding PuO_2 particle is 10 µm.
- The ability to determine average particle density for pre-leached and post leached solids.
- The ability to determine that the thermal conductivity of the sludge is >0.6 W/m K.
- The ability to determine that the specific heat capacity of the sludge is > 2.4 kJ/kg °C.
- The ability to determine that the settled non-convective layer in a vessel is 10% by volume.
- The ability to determine that the heat capacity for the non-convective layer is 2,850 J/(kg-K).

The types of analyses that will be performed in the Analytical Laboratory are described in the ISARD (Reference 6.14). The initial feed acceptance DQO are established in Reference 6.15 to identify the data collection requirements including sampling and analysis to support the evaluation of WAC parameters and the decision to accept the feed. The analytical capabilities to meet the currently established nuclear safety parameters have been defined. A comparison of the WAC requirements in ICD-19 (Reference 6.2) against the information provided in the ISARD and the DQO is provided in Table 1. The lightly shaded cells are current Nuclear Safety parameters that will be protected as TSRs.

Table 1 Comparison of Measured Process Parameters

Physical Property	Delivery Limit (ICD-19)	Sample Point[1] ISARD	DQO[2]	Notes
LAW Transfer Properties				
LAW transfer solids concentration	≤ 3.8 wt% solids measured after holding sample at 25 °C for 8 hours	TF 1 c	≤ 3.8 wt% solids measured after holding sample at 25 °C for 8 hours	The ISARD indicates that weight percent solids will be measured but does not specify a limit. The PDSA still reflects no solids > 5 wt%. The contract requirement is for ≤ 3.8 wt%.
Slurry pH	≥ 12	> 7 (TF 1 c)	> 7	The ISARD and DQO values differs from the ICD-19 requirements. The values in the ISARD and DQO are based on permit requirements.
Slurry bulk density ρ_{Mb} (kg/L)	< 1.46	TF 1 c	< 1.46	The ISARD indicates that the waste feed density will be measured but does not provide a limit.

Table 1 Comparison of Measured Process Parameters

Physical Property	Delivery Limit (ICD-19)	Sample Point[1] ISARD	DQO[2]	Notes
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe]	≤ 4.0	None	N/A	ICD-19 indicates that LAW feed critical velocity is not measured directly. DQO indicates critical velocity is not applicable since data point will not be measured.
HLW Transfer Properties				
HLW transfer solids concentration	≤ 200 g/L measured after holding sample at 25 °C for 8 hours	None	≤ 200 g/L measured after holding sample at 25 °C for 8 hours	The ISARD does not identify the solids concentration.
Slurry viscosity (at 25 °C)				The ISARD does not identify slurry viscosity.
- Consistency μ_c (cP)	< 10	TF 1 c	< 10	
- Yield stress τ_o (Pa)	< 1.0	TF 1 c	< 1.0	
Slurry pH	≥ 12	> 7 (TF 1 c)	> 7	The ISARD and DQO values differs from the ICD-19 requirements. The values in the ISARD and DQO are based on permit requirements.
Slurry bulk density ρ_{Mb} (kg/L)	< 1.5	None	< 1.5	The ISARD does not identify limits for density.
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe]	≤ 4.0	None	≤ 4.0	The ISARD does not identify critical velocity; however, critical velocity is not determined from a sample.
General Feed Parameters				
Ammonia NH_3	< 0.04M	< 0.04M (TF 1 c)	< 0.04M	
No separable organics	(not defined)	No visible (TF 1 b)	No visible	Contract deliverable 2.11 and ICD-19 indicate that BNI will propose a deminimus concentration level for separable organics that could be sent to WTP without adversely affecting the WTP.
PCBs	< 50 ppm	< 50 ppm (TF 1 c)	< 50 ppm	
PT LAW Feed unit dose	< 1500 Sv/L at 10M Na	None	< 1500 Sv/L at 10M Na	Criteria are not identified in the ISARD.
PT HLW Feed unit dose	< 2.9E+05 Sv/L (equivalent to 270 Sv/L as dry solids)	None	< 270 Sv/g dry solids	Criteria are not identified in the ISARD. 270 Sv/L as dry solids matches the entry for HLW in ICD-19

Table 1 Comparison of Measured Process Parameters

Physical Property		Delivery Limit (ICD-19)	Sample Point[1] ISARD	DQO[2]	Notes
Pu to metals loading ratio		< 6.20 g/kg	< 5.34 g/kg (TF 1 c)	< 6.20 g/kg	The ISARD value is outdated. CSER states < 6.20 (CSL 8.1)
U fissile to U total		< 8.4 g/kg	< 8.2 g/kg (TF 1 c)	< 8.4 g/kg	The ISARD value is outdated. CSER states < 8.4 (CSL 8.2)
Pu concentration of liquids		< 0.013 g/L	<0.013 g/L (TF 1 c)	< 0.013 g/L	
Total radioactivity in material fed to WTP per year from external sources		1.1 E8 Ci/yr	None	1.1 E8 Ci/yr	Not identified in the ISARD.
Hydrogen generation rate	LAW	3.7E-07 gmole H_2 / L / Hr @ 120 °F	TF 1 c	3.7E-07 gmole H_2 / L / Hr @ 120 °F	The ISARD states that rheology analyses for hydrogen mitigation are performed but does not specify the limits for tank farm samples.
	HLW	2.1E-06 gmole H_2 / L / Hr @ 120 °F	TF 1 c	2.1E-06 gmole H_2 / L / Hr @ 150 °F	
LAW Feed Temperature		< 120 °F	None	< 120 °F	The ISARD is associated with samples. Temperatures are not identified in the ISARD.
HLW Feed Temperature		< 150 °F	None	< 150 °F	The ISARD is associated with samples. Temperatures are not identified in the ISARD.
Specification 7 list of constituents and concentrations		Specification 7	TF 1 b (TS-7.1)	Table 4-2	The ISARD does not identify limits but does identify analytes and references limits identified in Specification 7 (Table TS 7.1 & 7.2)
Specification 8 list of constituents and concentrations		Specification 8	TF 1 b	Table 4-2	The ISARD does not identify limits but does identify analytes and references limits identified in Specification 8 (Table TS 8.1, 8.2, & 8.4)
Mean size particle		≤ 11 microns	Disrupted median solids particle size is < 22 microns (TF 1 c)	None	The DQO does not identify a particle size requirement. This is a known issue and is identified in ICD-19 Table 8, Note 6.
Arithmetic average particle hardness		≤ 4.4 Mohs	< 4.4 Mohs (TF 1 c)	None	The DQO does not identify a particle hardness requirement. This is a known issue and is identified in ICD-19 Table 8, Note 6.

Table 1 Comparison of Measured Process Parameters

Physical Property	Delivery Limit (ICD-19)	Sample Point[1] ISARD	DQO[2]	Notes

[1] Sample point from 24590-WTP-PL-PR-04-0001 (Reference 6.14)
[2] Data Quality Objectives from 24590-WTP-RPT-MGT-11-014 (Reference 6.15)

The criteria in ICD-19 must be verified prior to transferring the waste to the WTP. Those sample points identified by "TF" in Table 1 are taken at the tank farms. Once the waste has been transferred to the WTP, routine samples are taken and confirmed to meet the various requirements associated with the different stages of the vitrification process (e.g., process hold points). If parameters are not within acceptable limits for the next stage of the vitrification process, the affected parameter, such as pH, can be adjusted.

The DQO indicates that the pH value specified part of WTP permit (Reference 6.26) requirements to ensure compatibility with WTP construction material and treatment processes. The same pH value is identified in the ISARD. This value is non-conservative with respect to the acceptance criteria specified in ICD-19. This issue is being tracked by PIER item 24590-WTP-PIER-MGT-11-1292 (Reference 6.27).

The mean particle size identified in the ISARD differs from the criteria in ICD-19. The DQO does not specify the mean size particle or the arithmetic average particle hardness. ICD-19 Table 8, General Feed Parameters, Note 5, states that the Tank Operations Contractor baseline sampling plans and capabilities are not currently compatible with WTP sample and analysis requirements as described in the ISARD and the Regulatory Data Quality Optimization Report (Reference 6.28). Particle hardness and arithmetic average particle size values are included in the list of open items in ICD-19. Particle hardness and arithmetic average particle size are values not expected to measured directly, are under investigation, and will likely be replaced.

The Appendix C of the ISARD (Reference 6.14) provides a table containing sample points, frequencies, and key sample point details and requirements. The results of some of these samples will be used as hold points to confirm continued operation within the established safety basis. The ability to analyze the samples within required time frames would not have an impact on nuclear safety since the results of the analyses must be received prior to continuing with the next step in the waste treatment process.

5 Summary

The WAC for feed to the PTF from the tank farms is identified in ICD-19. Key inputs to these values are Specifications 7 and 8 of the contract, the PDSA, the PDSA Addenda, the CSER, and the BOD. The WAC that are associated with assumptions are the ULD values used to establish public receptor specific dose factors. The criticality limits in the WAC are based on assumptions in the CSER. Other WAC are associated with parameters established in the safety basis.

The PDSA has established limits on solids content for the specific vessels in the PTF as well as for median particle hardness concentration and particle size distribution. Parameters to limit hydrogen generation rates and dissolved ammonia concentrations have also been established. Other parameters to ensure the ability to mix the waste to control hydrogen buildup are also identified in the PDSA. Some of these parameters will be protected as TSR level controls. As discussed previously, the possible use of abrasivity limits on particle hardness in lieu of particle hardness concentration has been proposed but not yet incorporated into the PDSA or the WAC. This limitation may be changed and is currently being tracked as an open item in ICD-19.

The TSR level controls associated with sampling and analysis will be established as a SAC. Compliance with the SAC will require sampling and analysis of the feed streams to verify compliance with the parameters established in the safety basis.

Other candidates for TSR level controls associated with waste feed temperature and rheology are being considered. Potential new parameters for inclusion in the WAC are included in Section 4.4.2 and include pH, temperature, bulk density, viscosity, solids concentration, sodium content, feed particle size, shear strength, and PuO_2 particle size limitations. If selected, these requirements will be incorporated into the WAC. No changes to the WAC as currently identified in ICD-19 are currently proposed although additional waste stream related TSR level controls are expected.

Rheology limitations related to the ability of the PJMs to mix the waste in the vessels will be included and while the PDSA currently lists parameters associated with mixing, concerns with the ability of the PJMs to satisfy those requirements have been raised. In response to those concerns, large scale integrated testing is being conducted to determine the capabilities of the PJMs. Once those capabilities have been established, the appropriate parameters can be identified.

6 References

6.1 CCN 242510, Letter from S. Chu (DOE) to P. Winokur (DNFSB), Implementation Plan for Defense Nuclear Safety Board Recommendation 2010-2, Revision 0, dated November 10, 2011.

6.2 24590-WTP-ICD-MG-01-019, ICD-19 - Interface Control Document for Waste Feed, Revision 5, dated August 10, 2011.

6.3 Contract DE-AC27-01RV14136, Section C, Statement of Work, Conformed Through Modification No. 241.

6.4 24590-WTP-PSAR-ESH-01-002-01, Preliminary Documented Safety Analysis to Support Construction Authorization; General Information, Revision 4s, dated December 6, 2011.

6.5 24590-WTP-PSAR-ESH-01-002-02, Preliminary Documented Safety Analysis to Support Construction Authorization; PT Facility Specific Information, Revision 4w, dated December 7, 2011.

6.6 24590-WTP-PSAR-ESH-01-002-03, Preliminary Documented Safety Analysis to Support Construction Authorization; LAW Facility Specific Information, Revision 4p, dated September 29, 2011.

6.7 24590-WTP-PSAR-ESH-01-002-04, Preliminary Documented Safety Analysis to Support Construction Authorization; HLW Facility Specific Information, Revision 4w, dated December 19, 2011.

6.8 24590-WTP-PSAR-ESH-01-002-05, Preliminary Documented Safety Analysis to Support Construction Authorization; Balance of Facility Specific Information, Revision 4k, dated October 20, 2011.

6.9 24590-WTP-PSAR-ESH-01-002-06, Preliminary Documented Safety Analysis to Support Construction Authorization; Lab Facility Specific Information, Revision 3l, dated October 19, 2011.

6.10 24590-WTP-PSARA-ENS-09-0001, Preliminary Documented Safety Analysis - Control Strategy Changes for the PT Facility, Revision 6, dated October 11, 2011.

6.11 24590-WTP-CSER-ENS-08-0001, Preliminary Criticality Safety Evaluation Report for the WTP, Revision 0b, dated August 28, 2009.

6.12 CCN 204621, Conditional Approval of Bechtel National, Inc. (BNI) - 24590-WTP-RPT-NS-01-001, Rev 6, Preliminary Criticality Safety Evaluation Report (CSER) for the Waste Treatment and Immobilization Plant, dated August 27, 2009.

6.13 24590-WTP-DB-ENG-01-001, Basis of Design, Revision 1Q, Dated August 4, 2011.

6.14 24590-WTP-PL-PR-04-0001, Integrated Sampling and Analysis Requirements Document (ISARD), Revision 2, dated May 5, 2008.

6.15 24590-WTP-RPT-MGT-11-014, Initial Data Quality Objectives for WTP Feed Acceptance Criteria, Revision 0, dated May 19, 2011.

6.16 DOE G 424.1-1B, Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements, U.S. Department of Energy, Office of Health, Safety and Security, dated April 8, 2010.

6.17 24590-WTP-RPT-M-05-001, WTP Waste Particle Size and Hardness Characterization, Revision 0, dated May 13, 2005.

6.18 24590-WTP-RPT-ENG-08-021-06, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 6 - FRP-VSL-00002A/B/C/D, Revision 1, dated June 30, 2010.

6.19 Project Issues Evaluation Report 24590-WTP-PIER-MGT-12-0021, PDSA Not Updated to Reflect Maximum Entrained Solids for FRP-02 Vessels, dated January 5, 2012.

6.20 Hoyt, Richard C., Thomas Jones, and Joseph Teal, 2011. Historical Overview of Solids in PFP Aqueous Waste Transferred To Tank Farms: Quantity of Plutonium, Particle Size Distribution, and Particle Density, 24590-CM-HC4-W000-00176-T04-01-00001.

6.21 RPP-RPT-50941, Review of Plutonium Oxide Receipts into Hanford Tank Farms, Revision 0 dated 2011.

6.22 24590-WTP-RPT-ENG-08-021-08, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 8 - HLP-22, Revision 1, dated June 28, 2010.

6.23 24590-WTP-RPT-ENG-08-021-06, EFRT Issue M3 PJM Vessel Mixing Assessment, Volume 6 - FRP-VSL-00002A/B/C/D, Revision 1, dated June 30, 2010.

6.24 24590-WTP-RPT-ENG-08-021-03, EFRT Issue M3 Vessel Mixing Assessment, Volume 3 - HLP-VSL-00027A/B, HLP-VSL-00028, UFP-VSL-00002A/B, Revision 1, dated August 19, 2010.

6.25 24590-WTP-M4C-V11T-00011, Revised Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit for WTP, Revision C, dated May 7, 2010.

6.26 WA7890008967, Dangerous Waste Portion of the Hanford Facility Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste, Appendix 3A, Waste Treatment Plant Waste Analysis Plan.

6.27 Project Issues Evaluation Report 24590-WTP-PIER-MGT-11-1292, pH Inconsistencies for Waste Acceptance Criteria, dated December 19, 2011.

6.28 24590-WTP-RPT-MGT-04-001, Regulatory Data Quality Objectives Optimization Report, Revision 0, dated February 5, 2004.

6.29 24590-WTP-ATS-MGT-11-0559, ICD 19 Issue I19-47, Reconcile WTP/TOC Sampling Plan Incompatibilities, dated July 14, 2011.

Appendix A

Pages from WTP Contract No. DE-AC27-01RV14136 Specification 7, Low-Activity Waste Envelopes Definition

Specification 7: Low-Activity Waste Envelopes Definition

7.1 Scope: This Specification establishes three LAW feed envelopes, Waste Envelopes A, B, and C. Each waste envelope provides the compositional limits for chemical and radioactive constituents in the waste feed to be provided to the WTP. The WTP shall be designed to treat the waste envelopes with the limits established in this specification. Waste composition information from TFCOUP Revision 6 is used to establish overall WTP design capacity as defined in Section C.7 and is not otherwise used for design.

7.2 Requirements:

7.2.1 References:

7.2.1.1 HNF-SD-WM-SAR-067, Revision 1-I. March 2000. *Tank Waste Remediation System Final Safety Analysis Report*. CH2M HILL Hanford Group, Inc., Richland, Washington.

7.2.1.2 HNF-SD-WM-TSR-006, Revision 1-HE. March 2000. *Tank Waste Remediation System Technical Safety Requirements*, CH2M HILL Hanford Group, Inc., Richland, Washington.

7.2.1.3 OSD-T-151-00007, Revision H-22. June 14, 2000. *Operating Specification for 241-AN, AP, AW, AY, AZ, and SY Tank Farms*. CH2M HILL Hanford Group, Inc., Richland, Washington.

7.2.1.4 DOE/RL-88-21, Revision 10. December 21, 1999. *Double Shell Tank Unit Permits Application.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

7.2.2 Envelope Requirements:

7.2.2.1 Composition: This specification lists the concentration limits for the LAW Envelopes A, B, and C feed to be transferred by DOE to the Contractor for LAW services in Tables TS-7.1, *Low-Activity Waste Chemical Composition, Soluble Fraction Only,* and TS-7.2, *Low-Activity Waste Radionuclide Content, Soluble Fraction Only*. The concentration limits apply to the soluble fraction only. The Na concentration limits for the LAW feeds are identified below.

Waste Feed	Na (mole per liter)
Envelope A, B, C	4 – 10
AZ-101 Supernatant	2 – 5
HLW Slurry and other HLW Liquids (Defined in Specification 8, *High-Level Waste Envelope Definition*)	0.1 – 10*

*The feed delivery batch size shall be such that, after receipt in WTP and blending with pre-existing receipt tank contents, the sodium molarity will not exceed 7 **(M183)**.

The LAW feeds may contain up to 3.8 weight percent (wt%) solids and will be delivered to the WTP after there has been sufficient settling time to ensure solids that settle faster than 0.03 ft/min have settled below the transfer location within the tank farms feed tank **(M183)**. Solids are defined as the product of centrifuging the LAW feed, separating and drying the solids, and removing the dissolved solids contribution. The insoluble fraction characterization will include measurements of Al, Cr, Fe, Mn, Na, P, S, Si, U, TIC, TOC, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, ^{154}Eu, $^{239/240}$Pu, ^{241}Am, and total alpha concentrations. Trace quantities of unspecified radionuclides, chemicals, and other impurities may be present in the waste feed.

All LAW feed (soluble and insoluble components) will meet the Tank Farm Operations specifications given in OSD-T-151-00007 (except for free hydroxide), the *Tank Waste Remediation System Final Safety Analysis Report*, and *Technical Safety Requirements*, as applicable.

The radiochemical inventory of the LAW feed at the time of delivery shall be compared to the specification limits to assess compliance. The specifications for ^{60}Co, and ^{154}Eu shall apply at the time of delivery for ILAW immobilization.

The LAW feed provided shall not contain a visible separate organic phase.

The LAW feed provided will generate gases, including hydrogen and ammonia, at a nearly constant rate and a nearly uniform composition. The Contractor is responsible for the management of changes in gas release rate and distribution resulting from their waste processing activities.

Dangerous waste codes are identified in the *Double-Shell Tank System Unit Permit Application* (DOE/RL-88-21, December 21, 1999). Multi-source leachate (F039) is included as a waste derived from non-specific source wastes F001 through F005.

7.2.2.2 Radioactive Material Concentration: The maximum ^{137}Cs concentration equivalent in the transferred Envelope A, Envelope B, and Envelope C wastes feeds shall not exceed 1.2 Ci/l. The maximum ^{137}Cs concentration equivalent in the liquid fraction of Tanks AZ-101 and AZ-102 feeds shall not exceed 3.0 Ci/l.

Table TS-7.1 Low-Activity Waste Chemical Composition, Soluble Fraction Only

Chemical Analyte	Maximum Ratio, analyte (mole) to sodium (mole)		
	Envelope A	Envelope B	Envelope C[3]
Al	2.5E-01	2.5E-01	2.5E-01
Ba	1.0E-04	1.0E-04	1.0E-04
Ca	4.0E-02	4.0E-02	4.0E-02
Cd	4.0E-03	4.0E-03	4.0E-03
Cl	3.7E-02	8.9E-02	3.7E-02
Cr	6.9E-03	2.0E-02	6.9E-03
F	9.1E-02	2.0E-01	9.1E-02
Fe	1.0E-02	1.0E-02	1.0E-02
Hg	1.4E-05	1.4E-05	1.4E-05
K	1.8E-01	1.8E-01	1.8E-01
La	8.3E-05	8.3E-05	8.3E-05

Table TS-7.1 Low-Activity Waste Chemical Composition, Soluble Fraction Only

Chemical Analyte	Maximum Ratio, analyte (mole) to sodium (mole)		
	Envelope A	Envelope B	Envelope C[3]
Ni	3.0E-03	3.0E-03	3.0E-03
NO_2	3.8E-01	3.8E-01	3.8E-01
NO_3	8.0E-01	8.0E-01	8.0E-01
Pb	6.8E-04	6.8E-04	6.8E-04
PO_4	3.8E-02	1.3E-01	3.8E-02
SO_4	1.0E-02	7.0E-02	2.0E-02
TIC[1]	3.0E-01	3.0E-01	3.0E-01
TOC[2]	5.0E-01	5.0E-01	5.0E-01
U	1.2E-03	1.2E-03	1.2E-03

Notes:

1. Mole of inorganic carbon atoms/mole sodium.
2. Mole of organic carbon atoms/mole sodium.
3. Envelope C LAW is limited to complexed tank wastes from Hanford tanks AN-102 and AN-107.

Table TS-7.2 Low-Activity Waste Radionuclide Content, Soluble Fraction Only
Maximum Ratio, radionuclide to sodium (mole)

Radionuclide	Envelope A		Envelope B		Envelope C	
	Bq	uCi	Bq	uCi	Bq	uCi
TRU	4.80E+05	1.30E+01	4.80E+05	1.30E+01	3.00E+06	8.11E+01
^{137}Cs	4.30E+09	1.16E+05	2.00E+10	5.41E+05	4.30E+09	1.16E+05
^{90}SR	4.40E+07	1.19E+03	4.40E+07	1.19E+03	8.00E+08	2.16E+04
^{99}Tc	7.10E+06	1.92E+02	7.10E+06	1.92E+02	7.10E+06	1.92E+02
^{60}Co	6.10E+04	1.65E+00	6.10E+04	1.65E+00	3.70E+05	1.00E+01
^{154}Eu	6.00E+05	1.62E+01	6.00E+05	1.62E+01	4.30E+06	1.16E+02

Notes:

1. The activity limit shall apply to the feed certification date.

2. TRU is defined as: Alpha-emitting radionuclides with an atomic number greater than 92 with half-life greater than 20 years.

Some radionuclides, such as ^{90}Sr and ^{137}Cs, have daughters with relatively short half-lives. These daughters have not been listed in this table. However, they are present in concentrations associated with the normal decay chains of the radionuclides.

1Bq = 2.703 e-5 uCi

Appendix B

Pages from WTP Contract No. DE-AC27-01RV14136 Specification 8, High-Level Waste Envelope Definition

Specification 8: High-Level Waste Envelope Definition

8.1 Scope: This Specification establishes the HLW slurry composition and the unwashed solids composition (Envelope D). This waste envelope provides the compositional limits for chemical and radioactive constituents and physical properties in the waste feed to be provided to the WTP. The WTP shall be designed to treat the feed envelope with the limits established in this specification. Waste Composition information from TFCOUP Revision 6 is used to establish overall WTP design capacity as defined in Section C.7 and is not otherwise used for design.

8.2 Requirements:

8.2.1 References:

8.2.1.1 HNF-SD-WM-SAR-067, Revision 1-I. March 2000. *Tank Waste Remediation System Final Safety Analysis Report*. CH2M HILL Hanford Group, Inc., Richland, Washington.

8.2.1.2 HNF-SD-WM-TSR-006, Revision 1-HE. March 2000. *Tank Waste Remediation System Technical Safety Requirements*, CH2M HILL Hanford Group, Inc., Richland, Washington.

8.2.1.3 OSD-T-151-00007, Revision H-22. June 14, 2000. *Operating Specification for 241-AN, AP, AW, AY, AZ, and SY Tank Farms*. CH2M HILL Hanford Group, Inc., Richland, Washington.

8.2.1.4 DOE/RL-88-21, Revision 10. December 21, 1999. *Double Shell Tank Unit Permits Application*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

8.2.1.5 RPP-7475, Revision 0. December 7, 2000. *Criticality Safety Evaluation of Hanford Tank Farms Facility,* CH2M HILL Hanford Group, Inc., Richland, Washington.

8.2.1.6 CPS-T-149-00012, Revision A-3. March 14, 2002. *Criticality Prevention Specification - Tank Farms Operations*.

8.2.2 High-Level Waste Slurry Description and Envelope Requirements:

8.2.2.1 Composition: The HLW slurry will contain a mixture of liquids (Envelopes A, B, or C) and solids (Envelope D). The compositional range of the liquid fraction is defined in Specification 7, *Low-Activity Waste Envelopes Definition*. For liquid fractions with a sodium molarity of less than three (3), the liquid shall be treated as if 3 molar sodium were present for feed certification purposes. The *Radioactive Material Concentration* specification contained in Specification 7.2.2.2 does not apply to Envelope A, B, or C liquids. The composition range of the Envelope D unwashed solids is given in Tables TS-8.1, TS-8.2 and TS-8.3, and TS-8.4. The feed concentration will be between 10 and 200 grams of unwashed solids/liter, except for feeds from waste Tanks AZ-101 and AZ-102, where minimum-solids content does not apply. The feed delivery batch size will be such that, after receipt in WTP and blending with pre-existing receipt tank contents, the concentration will not exceed a linear range of 107 grams of unwashed solids/liter at 0.1 molar sodium up to 144 grams/liter at 7 molar sodium **(M183)**.

Compositions for Envelope D unwashed solids (Tables TS-8.1, TS-8.2 and TS-8.3, and TS-8.4) are defined in terms of elemental or anion concentrations and radionuclide activities per 100 grams equivalent non-volatile waste oxides. The non-volatile waste oxides include sodium oxide and silicon oxide.

The HLW feed components identified in Tables TS-8.1, TS-8.2, and TS-8.3 are waste components important to establishing the waste oxide loading in the HLW glass. Only these components have concentration limits, which will be used to provide the basis for certification that the HLW feed is within specification limits.

The HLW feed components identified in Table TS-8.4 are also important to HLW glass production. The concentrations of these components in the waste are not expected to exceed the maximum values listed in Table TS-8.4. Information on these components will be provided to support product and process qualification but will not be used as a basis for determining if the feed meets specification requirements.

All HLW feed (soluble and insoluble components) will meet the Tank Farm Operations specifications given in OSD-T-151-00007 (except for free hydroxide), the *Tank Waste Remediation System Final Safety Analysis Report* (HNF-SD-WM-SAR-067), and *Technical Safety Requirements* (HNF-SD-WM-TSR-006, Revision 1-D) as applicable. The radiochemical inventory of the waste feed at the time of delivery shall be compared to the specification limits to assess compliance.

Trace quantities of unspecified radionuclides, chemicals, and other impurities may be present in the waste feed. Feed will be delivered by pipeline in batches. Limits apply to the total retrievable contents of waste from a feed tank. Some elements, components, and isotopes are determined by calculation and not analytic measurement.

The HLW feed provided will not contain a visible separate organic layer.

The HLW waste provided will generate gases due to radiolysis including hydrogen and ammonia at a nearly constant rate and nearly uniform composition. The Contractor is responsible for the management of changes in gas release rate and distribution resulting from their waste processing activities.

Applicable dangerous waste codes are identified in the *Double-Shell Tank System Unit Permit Application* (DOE/RL-88-21, December 21, 1999). Multi-source leachate (F039) is included as a waste derived from non-specific source wastes F001 through F005.

Table TS-8.1 High-Level Waste Feed Unwashed Solids Maximum Non-Volatile Component Composition (grams per 100 grams non-volatile waste oxides)

Non-Volatile Element	Maximum (grams / 100 grams waste oxides)	Non-Volatile Element	Maximum (grams / 100 grams waste oxides)
As	0.16	Pu	0.054
B	1.3	Rb	0.19
Be	0.065	Sb	0.84
Ce	0.81	Se	0.52
Co	0.45	Sr	0.52
Cs	0.58	Ta	0.03
Cu	0.48	Tc	0.26
Hg	0.1	Te	0.13
La	2.6	Tl	0.45
Li	0.14	V	0.032
Mn	6.5	W	0.24
Mo	0.65	Y	0.16
Nd	1.7	Zn	0.42
Pr	0.35		

Table TS-8.2 High-Level Waste Feed Unwashed Solids Maximum Volatile Component Composition (grams per 100 grams non-volatile waste oxides)

Volatile Components	Maximum (grams / 100 grams waste oxides)
Cl	0.33
CO_3^{-2}	30
NO_2	36 (total NO_2/NO_3) as NO_3
NO_3	
TOC	11
CN	1.6
NH_3	1.6

Table TS-8.3 High-Level Waste Feed Unwashed Solids Maximum Radionuclide Composition (Curies per 100 grams non-volatile waste oxides)

Isotope	Maximum (Ci / 100 grams waste oxides)	Isotope	Maximum (Ci / 100 grams waste oxides)	Isotope	Maximum (Ci / 100 grams waste oxides)
^{3}H	6.5E-05	^{129}I	2.9E-07	^{237}Np	7.4E-05
^{14}C	6.5E-06	^{137}Cs	1.5E00	^{238}Pu	3.5E-04
^{60}Co	1E-02	^{152}Eu	4.8E-04	^{239}Pu	3.1E-03
^{90}Sr	1E+01	^{154}Eu	5.2E-02	^{241}Pu	2.2E-02
^{99}Tc	1.5E-02			^{241}Am	9.0E-02
^{125}Sb	3.2E-02	^{233}U	4.5E-06 (all tanks except AY-101/C-104)(2.0E-04 for AY-101/C-104 only)	$^{243+244}Cm$	3.0E-03
^{126}Sn	1.5E-04	^{235}U	2.5E-07		

Table TS-8.4 Additional High-Level Waste Feed Unwashed Composition for Non-Volatile Components (grams per 100 grams non-volatile waste oxides)

Non-Volatile Element	Maximum (grams / 100 grams waste oxides)	Non-Volatile Element	Maximum (grams / 100 grams waste oxides)
Ag	0.55	Ni	2.4
Al	14	P	1.7
Ba	4.5	Pb	1.1
Bi	2.8	Pd	0.13
Ca	7.1	Rh	0.13
Cd	4.5	Ru	0.35
Cr	0.68	S	0.65
F	3.5	Si	19
Fe	29	Ti	1.3
K	1.3	U	14
Mg	2.1	Zr	15
Na	19		
Th	5.0		

Appendix C

Pages from 24590-WTP-ICD-MG-01-019, ICD-19 - Interface Control Document for Waste Feed, Revision 5

2.4.3 Transfer Properties and Acceptance Criteria

Specification 7 and 8 provide the core LAW and HLW feed specifications. Table 5, Table 6, Table 7, and Table 8 provide waste feed transfer physical limits and waste feed acceptance criteria. Initial data collection requirements for feed transfer and acceptance criteria are documented in 24590-WTP-RPT-MGT-11-014, Initial Data Quality Objectives for WTP Feed Acceptance Criteria. This DQO was jointly developed by WTP and TOC.

The HLW slurry transfer flow rates, velocity, and head loss are a function of the waste properties. The solids properties of the HLW waste provided in Table 7 are identified as limits on the physical properties of the waste that can be pumped to the WTP and maintain critical flow velocities (avoid solids settling). These properties constitute the control limits necessary for effective transfers of waste within the existing WTP design limits of the equipment (including jumper connectors).

2.4.3.1 Transfer Properties

Table 5 Waste Feed Transfer Physical Limits

Transfer Property	Delivery Limit
Transfer flowrate	90 to 140 gal/min[Note 1] (CH2 2002a)
System design limits	400 lb/in^2 [Note 2] (Section 2.1.1) 200 °F (Section 2.1.1)
Pump discharge head	550 ft (90 gal/min) to 500 ft (140 gal/min) of slurry at 1.5 SpG (CH2 2002a)

Notes:

1 In a nominal 3-inch pipe, 90 to 140 gal/min equates to an approximate velocity of 4 to 6 feet per second.

2 Assumes jumper connections are leak test qualified to this limit

2.4.3.2 LAW Feed Waste Acceptance Criteria

Table 6 LAW Transfer Properties

Physical Property [1]	Delivery Limit (reference)
LAW transfer solids concentration	≤3.8 wt% Solids measured after holding sample at 25 °C for 8 hours[2] (BNI 2000, Specification 7)(BNI 2010f)
Slurry pH	≥ 12 (BNI 2009c)
Slurry bulk density ρ_{Mb} (kg/L)	< 1.46 (CH2 2002a)
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe] [3]	≤ 4.0 (CH2 2002a)

Notes:

1 See Appendix B for definitions of terms.

2 Solids will be delivered to the WTP after there has been sufficient settling time to ensure solids that settle faster than 0.03ft/min have settled below the transfer location within the tank farms staging tank.

3 LAW feed critical velocity is not measured directly.

2.4.3.3 HLW Feed Acceptance Criteria

Table 7 HLW Transfer Properties

Physical Property [1]	Delivery Limit (reference)
HLW transfer solids concentration	≤200 g/liter measured after holding sample at 25 °C for 8 hours (BNI 2000, Specification 8) (BNI 2010f)
Slurry viscosity (at 25 °C) – Consistency μ_c (cP) [3] – Yield stress τ_o (Pa) [3]	 < 10 (BNI 2002a) < 1.0 (BNI 2002a)
Slurry pH	≥ 12 (BNI 2009c)
Bulk density of slurry ρ_{Mb} (kg/L)	< 1.5 (CH2 2002a)
Critical velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe] [4]	≤ 4.0 (CH2 2002a)

Notes:

1 See Appendix B for definitions of terms

2 HLW feed batch size will be such that, after receipt in WTP and blending with pre-existing receipt tank contents, the concentration will not exceed a linear range of 107 grams of unwashed solids/liter at 0.1 molar sodium up to 144 grams/liter at 7 molar sodium.

3 Consistency, and yield stress are values used in WTP design but still under investigation as needed or applicable for waste feed acceptance.

4 HLW critical velocity will be measured by TOC.

2.4.3.4 General Feed Waste Acceptance Criteria

Table 8 General Feed Parameters

Physical Property	Delivery Limit (reference)	
Ammonia NH_3	< 0.04M (BNI 2006b)	
No separable organics [1]	(BNI 2000)	
PCBs	<50 ppm (Ecology 2002)	
PT LAW feed unit dose	<1500 Sv/L at 10M Na (WRPS 2009)	
PT HLW feed unit dose	<2.9E+05 Sv/L [Notes 2, 3] (BNI 2010)	
Pu to metals loading ratio [4]	<6.20 g/kg (BNI 2009a, CSL 8.1 & 8.4)	
U fissile to U total	<8.4 g/kg (BNI 2009a, CSL 8.2)	
Pu concentration of liquids	<0.013 g/liter (BNI 2009a, CSL 8.3)	
Total radioactivity in material fed to WTP per year from external sources	1.1 E8 Ci/yr (Health 2006)	
Hydrogen generation rate (BNI 2010d)	LAW	3.7E-07 gmole H_2 / L / Hr @120° F
	HLW	2.1E-06 gmole H_2 / L / Hr @150° F
LAW feed temperature	<120 °F (BNI 2005c)	
HLW feed temperature	<150 °F (BNI 2009b)	

Table 8 General Feed Parameters

Physical Property	Delivery Limit (reference)
Environmental Permit Limits (such as the Regulatory Data Quality Objectives (RDQO) report constituents, and negotiated concentrations limits) [5]	(BNI 2004a)
Specification 7 list of constituents and concentrations	(BNI 2000)
Specification 8 list of constituents and concentrations	(BNI 2000)
Mean size particle [6]	≤11 microns (BNI 2005d)
Arithmetic average particle hardness [6]	≤4.4 Mohs (BNI 2008b)

Notes:

1 The Contractor shall propose a deminimus concentration level for separable organics that could be sent to the WTP without adversely affecting the WTP (BNI 2000).

2 PT HLW feed unit dose, based on wet centrifuged solids.

3 The value for PT HLW feed unit dose is 2.9E05 Sv/L which is derived from HNF-IP-1266, *Tank Farms Operations Administrative Controls* as the bounding offsite ULD for solids. The WTP has converted this to 270 Sv/g for use in WTP calculations. The conversion of this is as follows: (2.9E05 Sv/L) / (0.66 * 1.63 * 1 g/cc * 1000 cc/L) = 270 Sv/g; where 0.66 is the fraction of solids and 1.63 is the specific gravity.

4 Sample analysis for solids shall credit Fe and Ni as the absorber metals and simulate the effects of wash/leach (CSL 8.1) Sample analysis for permeate Fe, Ni, Mn, and Cd are credited as absorber metals and simulate any subsequent processing, including wash/leach, Sr/TRU precipitation, and Cs ion exchange (CSL 8.4)

5 TOC baseline sampling plans and capabilities are not currently compatible with WTP sample and analysis requirements as described in Integrated Sampling and Analysis Requirements Document (ISARD) (24590-WTP-PL-PR-04-0001), Initial Data Quality Objectives for WTP Feed Acceptance Criteria (24590-WTP-RPT-MGT-11-014), and the Regulatory Data Quality Optimization Report (24590-WTP-RPT-MGT-04-001). Reconciliation of requirements and capabilities is ongoing (ICD Issue I19-47, Reconcile WTP/TOC Sampling Plan Incompatibilities, 24590 WTP-ATS-MGT-11-0559, TOC WBS 5.03.01.07.03).

6 See Appendix D, ICD 19 Open Items List, Item #15.

2.5 Emergency Returns

The TOC and WTP Contractor will prepare a detailed procedure for emergency transfers of feed back to the TOC receipt system. The procedure Scope and Entry Conditions sections will provide guidance for when the procedure should be implemented. Production of the Emergency Transfer Procedure is identified and tracked by Schedule ID 5HPC1TA095. The TOC will provide emergency reserve tank space of 1.1 million gallons (4,164 m^3) that is available to either the WTP or the TOC.

2.5.1 WTP to TOC Waste Return Acceptance Criteria

Specification 9, Liquids or Slurries Transferred to DOE by Pipeline (BNI 2000) and Tank Farms Waste Transfer Compatibility Program (SD-WM-OCD-015), define the transfer requirements that will be applied to waste returns. If, after sampling and analysis, the WTP Contractor determines that the waste transferred to the WTP receipt vessel is out of compliance, the WTP Contractor and DOE, will determine and take actions necessary to adjust the waste or seek DOE approval for transfer back to the TOC.