Integrated Sampling and Data Flow for Hanford Vitrification – 15337

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ABSTRACT

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) is a one-of-a-kind nuclear facility being designed, built, and commissioned for the U.S. Department of Energy (DOE) by Bechtel National, Inc. and its subcontractor URS Corporation. The WTP facilities are under construction to complete the design and construction, as well as planning to support the startup, commissioning, and operation for vitrifying the radioactive waste stored in aging underground tanks at the Hanford Site.

The work progress includes development of waste feed acceptance and qualification program, including methodologies for processing feed batches. Qualification data from staged feed samples will support the verification that waste acceptance criteria (WAC) and processability requirements are met. This verification is required to ensure safe operation of WTP processes for vitrifying the waste, while establishing specific campaign and batch sheets to comply with glass form acceptance requirements.

Sampling and data integration are critical for process control and monitoring of the feed through unit operations. Data collection begins with process knowledge of staged feed for determining the required WAC analyses and testing for unit operations. The waste feed qualification data form the baseline information for WTP operation. The qualification data will be tracked and compared with sample analyses at different steps in vitrification operation. All aspects of data life cycle will be managed by the WTP Plant Engineering organization. The data management approach is established in this manner to allow maintaining campaign traceability through glass production records, while safely processing the corresponding feed campaigns and complying with permitting requirements.

INTRODUCTION

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) facilities are being constructed to process and vitrify radioactive hazardous waste that is currently stored at the Hanford Site in underground tanks. The stored waste comprises highly radioactive solids and liquid fractions in the form of sludge, saltcake, and supernatant liquid. Retrieval operations by the Hanford Tank Operations Contractor (TOC) include staging of the waste for transfer of supernatant and slurry fractions to WTP receipt vessels in the Pretreatment (PT) Facility. The received waste in PT will be pretreated and separated into low-activity waste (LAW) supernatant feed and high-level waste sludge feed (HLW) fractions. Each separated feed fraction will then be transferred to the corresponding LAW or HLW Facility for combining with glass formers to form the immobilized high-level waste (IHLW) and immobilized low-activity waste (ILAW) glass products. In addition to the PT, HLW, and LAW Facilities, other facilities in WTP include the Analytical Laboratory (Lab) for process analytical support and the Balance of Facilities (BOF) for plant maintenance, support, and utility services. Definitions of the various process streams including the incoming feed have been developed as part of the basis for WTP facility design and process inputs. Estimates of the process stream properties and characteristics used for process modeling are updated regularly to ensure the estimates are consistent with the evolution of the design basis. The design and function of process units are detailed in the corresponding facility and system descriptions.

WASTE FEED SAMPLING AND DATA COLLECTION

The waste feed acceptance and qualification (WFAQ) program requirements for feed acceptance and receipt are in development. The program details are provided in 24590-WTP-PL-PENG-14-0004, *Waste Feed Qualification Program Plan* [1]. Acceptance and qualification of the staged waste feed campaign includes characterization and laboratory-scale testing of process unit operations prior to transfer to WTP. The feed waste acceptance criteria (WAC) are established through an interface process among WTP, TOC and the US Department of Energy (DOE). The WAC requirements are documented in 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed* [2]. Samples from the staged tank waste are to be collected for WFAQ analyses and testing to ensure the waste acceptance and processability requirements are met for protecting the WTP safety and technical basis. The feed acceptance parameters are listed in Tables 4-1 and 4-2 of 24590-WTP-RPT-MGT-11-014, *Initial Data Quality Objectives for WTP Feed Acceptance Criteria* (WAC-DQO) [3].

The WFAQ data are simultaneously evaluated for feed acceptance and to establish the supernatant and sludge processing conditions for the corresponding feed campaign. This evaluation serves to optimize the glass production and process throughputs. The results from the laboratory scale testing of the following key unit operations are to be used in the WTP processability evaluation and process flowsheet performance for each waste feed campaign.

- Waste concentration
- Sludge washing and leaching
- Cross-flow ultrafiltration
- Ion exchange for Cs-137 removal
- Glass fabrication and analysis

Samples from the staged waste are to be collected for qualifying and accepting the TOC staged feed. The samples are analyzed in accordance with WAC-DQO [3] to demonstrate compliance with WTP waste acceptance criteria, and tested per WFAQ program requirements to test unit operations at laboratory scale. Although eighteen parameters have been identified as WAC constituents, data collection includes an additional 240 parameters. These eighteen parameters (shown in TABLE I below) are directly associated with the plant design, safety, permitting, and processing limits. Hence, these are categorized as decision constituents for feed transfer and acceptance. The remaining 240 parameters are associated with regulatory compliance reporting, contractual compliance, baseline data for feed processability, and radioactive material inventory. These parameters are categorized as informational constituents for feed acceptance. The same data quality requirements apply for all of the 258 parameters, which are listed by category in the WAC-DQO [3]. Waste feed qualification testing results, including WAC data, assist in the evaluation of unit process responses and adjustment of operating parameters for optimizing the process flowsheet to meet operating throughputs. Data from staged waste feed are to be used as baseline information for campaign and batch sheets associated with corresponding feed campaigns. Since qualification data establishes acceptable processing range parameters in WTP campaign and batch sheets, the feed receipt volume in WTP receipt vessels is based on the waste feed qualification data to ensure campaign-specific waste processing strategy. Hence, the decision to accept the feed requires data collected from WFAQ program implementation.

TABLE I. Action limits and corresponding requirements for WTP decision parameters

Data Inputs		LAW Feed Action Limit Values	HLW Feed Action Limit Values	Requirement Basis
Bulk Density ρ (kg/L)		< 1.46 (kg/L)	< 1.5 (kg/L)	Design Basis requirements for WTP receipt vessels
Waste Feed pH		pH > 12	pH > 12	To ensure compatibility with WTP construction material and treatment processes; and comply with WTP permit requirements, pH > 7
Maximum Solids C_{wt} (wt. %)		≤ 3.8 wt.%	NA	WTP Contract definition for the receipt of LAW Feed supernatant Note: The solids concentration shall be measured after holding the sample at 25 °C for eight hours. If percent solids are greater than 3.8%, a settling rate test will be performed.
Maximum Solids (g/L)		NA	≤ 200 g/L	WTP Contract definition for the receipt of HLW feed sludge. The Contract requires a linear range of solids content in relation to Na molarity. WTP is required to manage feed receipt such that receipt vessels are in the range of ≤ 107 g/L at 0.1 M Na up to 144 g/L at 7 M Na. Solids content is dependent on staged feed, and concentrations above these levels will require action by the WTP contractor to limit the batch volume for acceptance of feed transfer. Note: The solids concentration shall be measured after holding the sample at 25 °C for eight hours.
Feed Unit Dose		< 1500 Sv/liter at 10 M Na	< 2.9E+05 Sv/liter dry solids	WTP Safety Analysis assumptions
Slurry Viscosity (at 25 °C)	Consistency (cP)	< 21 cP	< 10 (cP)	WTP design basis for HLW receipt vessel
	Yield stress (Pa)		< 1.0 (Pa)	
NH_3 (Ammonia)		< 0.04 M	< 0.04 M	WTP safety assumptions for receipt and process vessels
No Separable Organics		No visible immiscible layer		WTP Safety assumptions
Polychlorinated Biphenyls (PCBs)		< 50 ppm		WTP Dangerous Waste Permit compliance requirement
Total Organic Carbon (*TOC*)		< 10 wt. %		WTP Safety assumptions and Dangerous Waste Permit compliance requirement
Pu to Metals Loading Ratio		< 6.20 g/kg		Parameters for Criticality Safety Limits. All Pu isotopes are considered as Pu-239 in the Pu to metal ratio. The isotopes considered for fissile U mass are U-233 and U-235 only. U-233 is considered more reactive than U-235 by a factor of 1.25. U-238 is included with these two U isotopes for U_{Total} in the U ratio.
$U_{Fissile}$ to U_{Total} Ratio		< 8.4 g/kg		
Pu Concentration of Liquids		< 0.013 g/liter		
Na Molarity (M)		≤ 10 M		WTP Contract requirements for waste feed LAW Feed - Envelope A, B, C, 4 - 10 Na (M) LAW Feed - AZ-101 Supernatant, 2 - 5 Na (M) HLW Feed - 0.1 - 10 Na (M)
Hydrogen Generation Rate (HGR)		≤ 3.7E-07 gmole H_2/L/hr @ 120˚ F	≤ 2.1E-06 gmole H_2/L/hr @ 150˚ F	Design calculation limits for LAW Feed receipt vessels (FRP-VSL-00002A/B/C/D)
				Design calculation limits for HLW Feed receipt vessel (HLP-VSL-00022)
Feed Temperature (in-tank)		< 120 ˚F	< 150 ˚F	WTP vessel design requirements
Critical Velocity V_{cr} (ft/s) [in a nominal 3 inch diameter pipe, (*in-tank*)]		NA	≤ 4.0 ft/sec	Critical Velocity limit established to prevent settling or plugging in transfer lines. Applicable to HLW feed.

Data Inputs	LAW Feed Action Limit Values	HLW Feed Action Limit Values	Requirement Basis
Temperature Change (Waste Feed Compatibility)	< ± 20°C		WTP Dangerous Waste permit compliance requirement Waste feed compatibility to be evaluated using ASTM D5058-90 method that requires observing any temperature changes from mixing 10 mL of staged feed with 10 mL of residual waste from WTP feed receipt tanks. This evaluation is to ensure no changes in viscosity or potential incompatibilities adversely affecting waste processing.

WTP SAMPLING FREQUENCY

The frequency of sampling events and the number of samples taken at each sample point is based upon the need for analytical data to support processing decisions. No general rule applies because there are a number of criteria that drive the need to sample, such as those driven by process, waste characterization, regulatory, or safety needs. In general, a sample is taken soon after a vessel is filled, or when there is a need to verify the composition of material in a vessel or monitoring location. Multiple samples may be required from a sampling point during a single sampling event if the analyses require more volume than is available, or to address sampling and analytical uncertainty objectives.

PT FACILITY SAMPLING AND DATA COLLECTION

The PT Facility consists of a series of processing vessels located in black cells and a hot cell. The main function is to receive TOC waste, and then process and transfer the treated waste to HLW and LAW Facilities. In addition, the PT Facility function includes receipt, recycle, and management of liquid effluents from other WTP facilities.

The processing systems support the following activities:

- Receive and store waste feed from the Tank Operations Contractor (TOC)
- Concentrate waste feed, recycle streams, and treated LAW product to minimize the water load on the ultrafilters and LAW melter(s)
- Precipitate strontium (Sr) and transuranics (TRU) from selected waste for incorporation into HLW feed
- Blend appropriate amounts of HLW feed with LAW feed for use as feed to the ultrafilters
- Use the ultrafilters to concentrate solids, perform caustic and oxidative leaching of solids, and water wash solids
- Store pretreated HLW sludge for HLW vitrification feed
- Remove solids, strontium (Sr), transuranic elements (TRU), and cesium (Cs), and concentrate the resultant LAW feed
- Transfer the treated LAW supernatant to the LAW Facility and/or to a yet to be determined separate facility (such as the proposed Hanford Site 200 East Area Supplemental Treatment Plant for LAW pretreated waste)
- Blend pretreated HLW feed with the separated Cs, Sr, and TRU material previously removed from the LAW stream, and then transfer the blend to the HLW Facility

Samples at various locations in the facilities, including stack monitoring, are to be collected and analyzed to ensure processability, safety, and regulatory compliance. Identified sample points are associated with their respective feed receipt or processing vessels or monitoring locations. Details of PT sample hold points and data collection, including data usability, are provided in TABLE II. Hold points refer to the

situation where production cannot continue prior to receipt of the analytical results. PT non-hold sample points and respective locations are listed in TABLE III. See data requirements section for details.

LAW SAMPLING AND DATA COLLECTION

The LAW Facility provides the final treatment for the LAW feed fraction (supernatant liquid) and leachate from pretreatment of the HLW sludge after removal of the Cs, Sr, and TRU. The combined treated LAW supernatant from the PT Facility will be transferred as LAW feed to the concentrate receipt vessel (CRV) in the LAW facility where the CRV feed is to be sampled (at sample point LAW 1) and analyzed to determine the glass formulation recipe for adding the glass forming chemicals (GFCs). The LAW 1 sample point is considered a "hold point;" i.e. production cannot continue prior to receipt of the analytical results. The CRV feed is transferred to melter feed preparation vessels (MFPVs) and combined with GFCs. The MFPV is sampled (at sample point LAW 6) to verify the GFC addition and transferred to melter feed vessels (MFVs) for subsequent transfer to high temperature melters for vitrifying the waste as immobilized low-activity waste (ILAW) glass product. Sampling capability exists for the MFVs, should it be necessary to obtain a sample prior to transfer to the melter. However, these are not routine sample points. Capability exists to sample the ILAW glass product (at sample point LAW 2) when requested by DOE to confirm acceptability. In addition, samples at other locations in LAW, including stack monitoring, are to be collected and analyzed to ensure processability, safety, and regulatory compliance. Identified sample points are associated with their respective processing vessels or monitoring locations. Refer to TABLE II for details on LAW sample hold points. LAW non-hold sample points and respective locations are listed in TABLE III.

HLW SAMPLING AND DATA COLLECTION

The HLW vitrification facility provides final treatment for the HLW feed fraction (sludge) and the separated Cs, Sr, and TRU from the LAW feed. The combined HLW feed will be transferred from the PT Facility as blended HLW feed to the MFPVs in the HLW facility where the MFPV feed is to be sampled (at sample point HLW 2a) and analyzed to determine the glass formulation recipe for adding the GFCs. The contents are again sampled in MFPVs (at sample points HLW 2b and c) following GFC addition, and analyzed to confirm the composition for product compliance. Sample points HLW 2a/2b are considered "hold points;" i.e., production cannot continue prior to receipt of analytical data. The data from analyses of hold point samples require rapid turnaround to avoid impacts on subsequent processing operations and throughputs. The need for rapid turnaround analyses prompted WTP to develop the hot cell procedure, Laser Ablation-Inductively Coupled Plasma-Atomic Emission Spectroscopy (LA-ICP-AES), for multi-elemental analyses of HLW sludge samples. This developed method is planned to be implemented in the WTP hotcell laboratory to support rapid turnaround analyses. The MFPV feed is transferred to MFVs following verification of data from hold point sample HLW 2b. The capability exists to sample the IHLW product (at sample point HLW 7) when requested by DOE to confirm acceptability. In addition, samples at other locations in HLW, including stack monitoring, are to be collected and analyzed to ensure processability, safety, and regulatory compliance. Identified sample points are associated with their respective processing vessels or monitoring locations. Refer to TABLE II for details on HLW sample hold points. HLW non-hold sample points and respective locations are listed in TABLE III.

LAB SAMPLING AND DATA COLLECTION

The WTP Lab is a standalone facility that provides chemical and radiochemical analytical support for safe and compliant WTP operations. The Lab is designed to support analyses to provide the necessary process control, as well as environmental, regulatory, contractual compliance, safety, and limited technology

development for WTP operations. The Lab facility includes hotcells and radiochemical fume hoods located in areas designated as Analytical Hotcell Laboratory (AHL) and Analytical Radiological Laboratory (ARL). Both AHL and ARL are planned to be furnished with equipment and instrumentation to handle samples, perform separations, conduct chemical and radiochemical analyses, perform physical property measurements, automate data collection, and dispose of laboratory generated wastes.

The Lab facility is planned to routinely receive samples for analysis from LAW, PT, and HLW facilities via pneumatic transfer lines in the autosampling system (ASX). Also, manual grab samples from non-ASX locations and BOF sampling points are received in the Lab. The frequencies of sampling and types of analyses are compiled in the sampling and analysis document, 24590-WTP-LAB-PL-OP-12-0001, *Integrated Sampling and Analysis Plan* (ISAP) [4]. The sampling schedules are based on the production of 6.0 metric tons of glass (MTG) per day IHLW and 30 MTG per day ILAW. These production rates project an analytical support workload of about 10,000 samples per year.

The samples within the Lab facility are to be collected and analyzed mainly for stack monitoring, and for equipment/instrument calibration check or control standards to ensure analytical performance, safety, and regulatory compliance. Identified sample points are associated with their respective monitoring locations. The LAB contains no hold points and consequently does not appear in TABLE II. LAB non-hold sample points and respective locations are listed in TABLE III.

BOF SAMPLING AND DATA COLLECTION

The BOF includes 20 groups which support the operations within the PT, LAW, HLW, and Lab facilities. These groups are collectively referred to as BOF, and consist of seven functional groups: Power, Steam, Water, Air, Process Support, Facilities Waste, and Miscellaneous Support for WTP. Specific operational requirements are established to provide BOF the aforementioned support systems and utilities, as well as supplying reagents, and receiving and transferring secondary aqueous wastes from WTP to Hanford site treatment and/or disposal facilities like Liquid Effluent Retention Facility/Effluent Treatment Facility (LERF/ETF) and Treated Effluent Discharge Facility (TEDF). The sampling and data collection for BOF are associated with chemical reagents, nonradioactive effluents, demineralized water, boiler feeds, and offgas monitoring from steam boilers. The BOF contains no hold points and consequently does not appear in TABLE II. BOF non-hold sample points and respective locations are listed in TABLE III.

STACK EMISSIONS

The treated gaseous emissions to be discharged to the atmosphere from WTP stacks within appropriate permit limits are not secondary wastes. Airborne emissions are to be treated using emission control technologies as specified in approved air permits. WTP has obtained air permits for both radioactive and nonradioactive emissions.

Radioactive Air Emissions

The radioactive air permits are in place from the Washington State Department of Health (WDOH) to regulate radioactive emissions from nineteen WTP emissions units. Sampling and monitoring requirements are identified in the WDOH permits along with limits on specific activities within each emission unit, and required compliance with specific codes and standards.

Non-Radioactive Air Emissions

WTP nonradioactive air emissions permits are in place from the Washington State Department of Ecology to address the toxic air pollutants and prevent significant deterioration of emissions units. Each of the nonradioactive air permits regulates emissions of select criteria pollutants and all toxic air pollutants at WTP.

SECONDARY WASTE SAMPLING AND DATA COLLECTION

The projected secondary hazardous waste streams primarily belong to three categories – solid mixed wastes, radioactive liquid wastes, and non-radioactive dangerous wastes.

Secondary solid mixed wastes are to be generated from the WTP waste processing and maintenance activities. These wastes include fouled or worn ultrafilter media, spent ion exchange (IX) resins, contaminated consumable components of the melters and process offgas systems, the melters, and a number of maintenance wastes such as failed equipment and degreasing or decontamination materials. These wastes are to be placed into drums or boxes or specially designed containers for transferring to TOC for further treatment and/or disposal.

The WTP Radioactive liquid waste disposal system (RLD) will collect secondary liquid wastes generated by most WTP facilities. The RLD will receive effluent wastes from a wide variety of processes and drains including, but not limited to, laboratory analytical processes, high efficiency mist eliminator drains, process condensates from evaporators, caustic waste from the LAW Facility caustic scrubber, spent reagents from the resin addition process, vessel washes, floor drains and sumps, and vessel vent header drains. To the extent practical, RLD effluents are to be recycled back into the WTP treatment process; however, excess evaporator condensates and other effluents are to be transferred to the LERF/ETF.

Dilute radioactive and dangerous process waste liquid effluents discharged from the PT Facility RLD system are expected to meet acceptance criteria for discharge to the LERF/ETF. The nonradioactive dangerous wastes are to be generated by WTP operations, laboratory, and maintenance activities. These wastes are packaged at the WTP for transfer to a permitted treatment, storage, and disposal (TSD) facility.

Secondary wastes are to be sampled, characterized, and transferred to the Hanford site for treatment and/or disposal. The type and amount of secondary waste is dependent on waste generation. Sampling requirements and data collection depend upon waste generation profiles.

DATA REQUIREMENTS

Sample points identified in this section are based on current baseline planning for the processing strategy. These sample points are subject to change during startup, commissioning, and/or WTP contractual baseline change. The sample points integrated with data collection requirements are tabulated to correspond with data usability. Details of hold point sampling are shown in TABLE II below. The waste feed qualification data collected prior to feed campaign acceptance serves as the baseline information for WTP operation. The qualification data are to be tracked and compared with sample analyses at different steps in the vitrification operation. This includes evaluation and usability of collected data for subsequent steps during feed processing through WTP unit operations, as well as providing inputs to glass formulation/production records, effluents discharges, emissions monitoring, regulatory compliance reporting, and generation of waste profiles for secondary wastes.

TABLE II. WTP hold point sampling and requirements for data use

System Name Sample Point and Type Location	Analytes/Sampling Event	Basis for Data Use	Requirements for Data Use
Waste Feed Receipt Process System (FRP) PT 2 Whole sample FRP-VSL-02A/B/C/D WTP Waste Feed Receipt Vessel Hold point	Pu-239, Sr-90, isotopic U, Gamma emitters, Density, Total Solids, Phosphate, Al, Cd, Cr, Fe, Mn, Na, Ni, Th, Zr, TRU (Pu, Np, Am, Cm isotopes), HGR Constituents (*TOC*, alpha, beta, gamma emitters), pH, Particle Size Distribution), Rheology (Viscosity and Yield Stress), Free Hydroxide, No Separable Organics	Verify composition and processability of received feed. The results are compared with waste qualification data to assess the compatibility of the heel residue in the receipt tanks. This includes criticality analysis. Verification of feed acceptance and criticality safety limits.	Verify WAC results: Al, Free Hydroxide: Na: 4 M - 10 M (Envelope A, B, C) 2 M – 5 M (AZ-101 Supernatant) Total Suspended Solids: ≤ 3.8 wt% Density < 1.46 g/mL pH > 12 HGR: ≤ 3.7E-07 gmole H_2/L•hr @ 120 °F. Use Total Organic Content, alpha, beta, and gamma analysis data to calculate HGR values for comparing with measured HGR from feed qualification results. Rheology/Viscosity: ≤ 21.3 cP Rheology/Yield Stress: N/A Separable Organics: None Phosphate: Verify WAC Results Elemental: N/A
Waste Feed Receipt Process System (FRP) PT 2 Solids fraction FRP-VSL-2A/B/C/D WTP Waste Feed Receipt Vessel Hold point	Gamma emitters, Total Suspended Solids, Oxalate, Phosphate, Sulfate, Al, Bi, Ca, Cd, Cr, Fe, Mn, Na, Ni, Si, Th, U, Zr, Pu-239, U-233, U-235, U-238	To verify the composition and processability of the solids fraction in the waste feed by performing analysis on select parameters to compare with data obtained during waste qualification, including criticality analysis. Verification of feed acceptance and criticality safety limits.	$U_{fissile}$ to U_{total} Ratio (U-233, U-235, and U-238): ≤ 8.4 g Ufissile/ kg Utotal Pu-239: < 6.2 g / kg of absorbers (Fe, Ni, Cd, Mn) Al (insoluble), Bi, Ca, Si, U, Cr, Sulfate, Phosphate, Oxalate: Verify WAC Results Elemental: Verify WAC Results

System Name Sample Point and Type Location	Analytes/Sampling Event	Basis for Data Use	Requirements for Data Use
Waste Feed Receipt Process System (FRP) PT 2 Liquid fraction FRP-VSL-2A/B/C/D WTP Waste Feed Receipt Vessel Hold point	Sr-90, TRU (Pu, Np, Am, Cm isotopes), Gamma emitters, Sulfate, Na, Pu-239, U-233, U-235, U-238, *TOC*, Free Ammonium ion/Ammonia	Data needed to determine if liquid fraction meets processability requirements and to verify the composition for safety limits.	Sulfate < 1.0 E-02 (Envelope A) < 7.0 E-02 (Envelope B) < 2.0 E-02 (Envelope C) *TOC* ≤ 10% Ammonium ≤ 0.04 M (or free NH_3 in vapor) Na: 5 M - 10 M (Envelope A, B, C) 2 M - 5 M (AZ-101 Supernatant) Pu-239: < 0.013 g/L U_{fissle} to U_{total} Ratio (U-233, U-235, and U-238) < 8.4 g / kg Sr, TRU (Pu, Np, Am, Cm isotopes): Verify WAC Results
HLW Lag Storage And Feed Blending Process System (HLP) PT 13 Whole sample HLP-VSL-28 HLW Feed Blending Vessel Hold point	Sr-90, Total Solids, Cs-137, Ag, Al, B, Ba, Bi, Ca, Cd, Cr, Fe, K, La, Li, Mg, Mn, Na, Pb, Sb, Si, Sr, Th, Ti, Tl, U, Zn, Zr, Chloride, Fluoride, Nitrite, Nitrate, Phosphate, Sulfate, Total Inorganic Carbon, *TOC* , Rheology (Viscosity and Yield Stress), Free Hydroxide	Data needed for processability in HLW Facility.	Rheology/viscosity: ≤ 30 cP Rheology/yield stress: ≤ 30 cP Results for elemental, anions, and other analytes are required for feed composition reporting.
HLW Lag Storage And Feed Blending Process System (HLP) PT 17a Whole sample HLP-VSL-22 HLW Feed Receipt Vessel Hold point	Density, Total Solids, Total Suspended Solids, Total Dissolved Solids, Phosphate, Al, HGR constituents (*TOC*, Alpha, Beta, Gamma emitters), pH, Rheology (Viscosity and Yield Stress), Free Hydroxide, No separable organics	Data needed for criticality safety, feed verification, and to set process parameters. Verification of feed acceptance and criticality safety limits	Undissolved Solids: ≤ 107 g/L @ 0.1 M Na < 144 g/L @ 7 M Na pH > 12 Density < 1.5 kg/L Rheology/Viscosity: < 10 cP Rheology/Yield Stress: < 1Pa HGR: ≤ 2.1E-06 gmole H_2/L•hr @ 150 °F Use *TOC*, alpha, beta, and gamma analysis data to calculate HGR values for comparing with measured HGR from feed qualification results. Separable Organics: None Verify waste qualification results: Al, Phosphate Free Hydroxide: required to control washing and leaching in UFP process

System Name Sample Point and Type Location	Analytes/Sampling Event	Basis for Data Use	Requirements for Data Use
HLW Lag Storage And Feed Blending Process System (HLP) PT 17 Solids fraction HLP-VSL-22 HLW Feed Receipt Vessel Hold point	Total Solids, Phosphate, Sulfate, Oxalate, Al, Bi, Ca, Cd, Cr, Fe, Mn, Na, Ni, Si, Th, U, Zr, Pu-239, U-233, U-235, U-238	Data needed for criticality safety, feed verification, and set process parameters. Verification of feed acceptance and criticality safety limits	Al, Cr, Na, Phosphate, Sulfate, Oxalate, Si, Ca, U, Bi: Verify WAC results Pu-239: ≤ 6.2 g/kg of absorbers (Fe, Ni, Cd, Mn) U_{fissle} to U_{total} Ratio (U-233, U-235, and U-238) < 8.4 g $U_{fissile}$/ kg U_{total}
HLW Lag Storage And Feed Blending Process System (HLP) PT 17b Liquid fraction HLP-VSL-22 HLW Feed Receipt Vessel Hold point	Pu-239, Sr-90, Sulfate, Na, TRU (Pu, Np, Am, Cm isotopes), U-233, U-235, U-238, *TOC*, Free Ammonia, Free Hydroxide	Data needed for criticality safety, feed verification, and set process parameters.	Sulfate: < 0.65 wt% oxide Free hydroxide: required to control washing and leaching in UFP process Na: 0.1 M - 7 M Pu-239: < 0.013 g/L U_{fissle} to U_{total} Ratio (U-233, U-235, and U-238): < 8.4 g $U_{fissile}$/ kg U_{total} Verify waste qualification results: Sr-90, TRU *TOC* : ≤ 10% Ammonium ion: ≤ 0.04 M
Cesium Ion Exchange Process System (CXP) PT 28 Whole sample CXP-VSL-26A/B/C Treated LAW Collection Vessels Hold point	Boil down, Total Alpha, Total Beta, Cs-137, Na	Data needed to ensure sufficient removal of Cs-137 and verify that treated LAW will meet glass formulation limits.	Cs-137 (gamma scan): ≤ 9.5E-02 µCi/mL Gross alpha: < 1.6E-02 µCi/mL Gross beta: < 1.6E-02 µCi/mL Na: 2-10 M Boil down: verify waste qualification results
Spent Resin Collection And Dewatering Process System (RDP) PT 31b Liquid fraction RDP-VSL-2A/B/C Spent Resin Collection Vessels Hold point	Cs-137, Total Suspended Solids	Decide if the transport liquid is sufficiently low in Cs-137 and free of resin fines.	Total Suspended Solids: ≤ 2 wt% fast settling solids and/or evaporator concentration will not exceed the solids limit of 8 wt% in the separator vessel

System Name Sample Point and Type Location	Analytes/Sampling Event	Basis for Data Use	Requirements for Data Use
Radioactive Liquid Waste Disposal System (RLD) PT 35 Whole sample RLD-VSL-17A/B Alkaline Effluent Vessels Hold point	Total Alpha, Total Beta, Gamma emitters, Total Suspended Solids, Chloride, Fluoride	Data needed to decide if the contents of the Alkaline Effluent Vessels will be within LERF/ETF requirements as specified for PT-27.	Chloride: < 0.3 g/L Fluoride: < 0.3 g/L Total Suspended Solids: < 5% volume of particles > 5 μm Gross alpha: LDL ≤ 1.0 nCi/mL Gross beta: LDL ≤ 1.0 nCi/mL Gamma scan: LDL ≤ 1.0 nCi/mL
LAW Concentrate Receipt Process System (LCP) LAW 1a Whole sample LCP-VSL-1/2 LAW Concentrate Receipt Vessels Hold point	Sr-90, Loss On Ignition, Cs-137, Cm-242, Np-237, Pu-242, U-233, U-235, U-238, Pu-241, Tc-99, *TOC*, TRU (Pu, Np, Am, Cm isotopes), Al, B, Bi, Ca, Cr, Fe, K, Li, Mg, Na, P, S, Si, Ti, Zn, Zr, Chloride, Fluoride, Nitrite, Nitrate	Analyte concentrations determined from this sample point are required to calculate the addition of GFCs.	Sr-90 < 20 Ci/m^3 in ILAW glass Cs-137 < 3 Ci/m^3 in ILAW glass Tc-99 < 0.003 Ci/m^3 in ILAW glass Data input for LAW glass formulation algorithm and ILAW production records.
HLW Melter Feed Process System (HFP) HLW 2a Whole sample HFP-VSL-1/5 HLW Melter Feed Prep Vessels before GFC Hold point	Total Alpha, Total Beta, Loss On Destruction (metal-oxide conversion), Loss On Ignition, Cs-137, Total Inorganic Carbon, *TOC*, Chloride, Fluoride, Nitrite, Nitrate, Sulfate, Ag, Al, B, Ba, Bi, Ca, Cd, Cr, Fe, K, La, Li, Mg, Mn, Na, Ni, P, Pb, Sb, Si, Sr, Th, Ti, Tl, U, Zn, Zr	Analyte concentrations determined from this sample point are required to calculate the addition of GFCs.	Data input for HLW glass formulation algorithm.
HLW Melter Feed Process System (HFP) HLW 2b Whole sample HFP-VSL-1/5 HLW Melter Feed Prep Vessels before GFC Hold point	Sr-90, Eu, Hg, Cs-137, I-129, Chloride, Fluoride, Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Gd, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pd, Pr, Ra, Rb, Rh, Ru, S, Sb, Se, Si, Sm, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn, Zr	Confirm proper GFC addition and report product chemical composition	Verify GFC addition in the melter feed. Data from HLW 02b and 02c are used for IHLW production records.

In addition to TABLE II, data from non-hold sample points listed in TABLE III are required to support WTP process control and monitoring. Data requirements for the non-hold sample points are being developed.

TABLE III. WTP non-hold points and corresponding locations

Sample Point	Sample Location
PT 4	Ultrafiltration Feed Vessel
PT 5	Ultrafiltration Feed Prep Vessel
PT 6b	Ultrafiltration Permeate Vessels
PT 7	Vessel Vent Caustic Scrubber
PT 10	Cs Evaporator Recovered HNO_3 Vessel
PT 11a	Plant Wash Floor Drain Collection Vessels
PT 11b	C2 Floor Drain Collection Vessel
PT 12a	Plant Wash Vessel
PT 14a	Acidic/Alkaline Effluent Vessel
PT 16f/g	HLW Lag Storage Vessel
PT 18a	Fresh Resin Addition Vessel
PT 23a/b/c/d/e/f/h/i/j	Stack Sampling
PT 24	Steam Condensate Water Loop
PT 25	Recirculating Water Cooling Loop
PT 26	Recirculating Chilled Water Cooling Loop
PT 27	Process Condensate Vessels
PT 31a	Spent Resin Collection Vessel
PT 32	Treated LAW Concentrate Storage Vessel
PT 33	Water Feed Evaporator Feed Vessels
PT 34	LAW SBS Condensate Receipt Vessels
LAW 1b	LAW Concentrate Receipt Vessels
LAW 2	Glass shard from Container Decontamination Room
LAW 3	Plant Wash Vessel
LAW 6	LAW Melter Feed Prep Vessels
LAW 7	SBS Condensate Vessel Cooling System
LAW 9a/b	C1/C2 Drain Collection Vessel
LAW 10	SBS Condensate Collection Vessel
LAW 12b/c/d/e/f/g	Stack Monitoring
LAW 13	Melter Pour Caves Chill Water
LAW 14	Melter 1, 2 Cooling Water
LAW 15	Melter Power Supply Cooling Water
HLW 2c	HLW Melter Feed Prep Vessels before GFC Addition
HLW 3	Plant Wash and Drains Vessel (RLD)
HLW 4	HLW Acidic Waste Storage Vessel
HLW 7	Glass shard from Canister Decontamination Room
HLW 10a/b	HLW C2 Drains Collection Vessel
HLW 16	Melter Cooling Water Loop Monitoring
HLW 17a/b/c/d/e/f/g	Stack Monitoring
LAB 1a/b/c	LAB Stack Sampling
LAB 2-4	Verification Standards for LAB
BOF 1-11	Reagent Storage Tanks
BOF 13	Chilled Water
BOF 14	Cooling Tower

Sample Point	Sample Location
BOF 15a/b	Nonradioactive Effluent Tank
BOF 16	Demineralized Water Storage Tank
BOF 17a/b	Package Deaerator and Boiler Feed
BOF 20	Verification of inline monitor for 0.5M HNO_3 stream
BOF 21a/b/c/d/e/f	BOF Stack Monitoring

DATA FLOW AND CAMPAIGN / BATCH SHEETS

Batch processing is implemented through flow down of system design parameters, tank waste data, and waste qualification results into Campaign Sheets and Batch Sheets. The Campaign Sheets establish the initial parameters for treating the TOC staged waste campaign, and the associated batches in the campaign, through WTP process operations. A campaign is defined as one or more waste batches having similar physical and chemical properties that are tracked and managed as a unit. There is one Campaign Sheet for the HLW Facility, one Campaign Sheet for the LAW Facility, and three Campaign Sheets for the PT Facility. The PT Facility feed campaigns are controlled by the following three Campaign Sheets: waste feed receipt process system (FRP) Campaign Sheet (comprising LAW Feed), HLW lag storage and feed blending process system (HLP) Campaign Sheet (comprising HLW Feed), and ultrafiltration process system (UFP) / waste feed evaporation process system (FEP) / treated LAW evaporation process system (TLP) Campaign Sheet (comprising LAW and HLW feeds as well as process recycles to be processed through the filtration, washing, leaching, ion exchange, and evaporation systems).

Batch Sheets identify the parameters necessary to treat waste in a specific batch operation, and are planned to be used with the system operations manual to control each of the batch processes. Batch Sheets are not developed for continuous process vessels. The key parameters in Batch Sheets include feed campaign identification references, authorizations, waste process conditions (such as time and temperature), and target transfer volumes for waste and chemical additions. Batch Sheets are planned to be used with the system operations manual to control batch processes where waste processing parameters change from batch to batch, based on waste composition. There are batch processes that are controlled by procedure only, and do not have Batch Sheets because there are no process parameters that change from batch to batch.

Batch processes that do not require Batch Sheets may have Batch Records. A Batch Record documents key parameters and observations from a processed batch, including actual volume, mass, or processing values recorded in the Batch Sheet or operating procedures, as well as the processing knowledge, data, results, observations, or lessons learned which could be useful for future batches. Batch Records may be produced both for batches that have Batch Sheets and for batches that do not have Batch Sheets. Included with each Batch Sheet Parameter is an identification number. Parameter identification numbers are used to identify data referenced in the Data Flow Diagrams (DFDs). A DFD is the graphical representation of the flow of data through a process. It identifies where data are being produced, where they are stored, and where they will be used to support the Batch Processing Methodology.

CONCLUSIONS

The WFAQ data collection approach for feed acceptance and receipt is planned to serve as the baseline feed characteristics for the corresponding campaign. This baseline data in turn establishes the campaign and batch sheets to maintain feed traceability and integration of data flow with sampling points at various stages of WTP processing operations. The results from process sample points are planned to be used for

verifying the parameters and conditions in campaign and batch sheets that are established using WFAQ data. In addition, the process data serve as a comparison to the WTP baseline knowledge, which will be established for the incoming feed using data from waste feed acceptance and qualification. This baseline will serve to verify system performance and monitoring trends. The LAW and HLW compliance point data are planned to be used for glass formulation algorithms including ILAW and IHLW production records, while the data from stack emissions, effluent discharge monitoring, and secondary waste generation are planned to be used for permit and disposal compliance.

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