Dynamic (G2) Model Design Document, 24590-WTP-MDD-PR-01-002, Rev. 12

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

**P.O. Box 450
Richland, Washington 99352**

Dynamic (G2) Model Design Document, 24590-WTP-MDD-PR-01-002, Rev. 12

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Date Published
October 2011

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Office of River Protection

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APPROVED

By Julia Raymer at 1:26 pm, Dec 16, 2013

Release Approval

Date

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Dynamic (G2) Model Design Document

Document title:

Document number: 24590-WTP-MDD-PR-01-002, Rev 12

Contract number: DE-AC27-01RV14136

Department: Process Engineering

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Issue status: Approved

Approved by: Ernest D. Lee

Approver's position: Lead, Flowsheet Modeling

Approver's signature:

Signature

10/27/2011
Date

History Sheet

Rev	Reason for revision	Revised by
0	Initial Issue	C Henley
1	Added Appendix G with references; updated FEP-VSL-00017A and FEP-VSL-00017B attributes in Appendix F.	C Henley
2	Updated Appendix C; Updated attributes in Appendix F; Updated procedures in Appendix G.	C Henley
3	Updated Model Design Document to support version 1.2 of the model to incorporate MCRs 24590-WTP-MCR-PT-02-189, 24590-WTP-MCR-PT-02-190, 24590-WTP-MCR-PT-02-191, and 24590-WTP-MCR-PT-02-194. Document rewritten and changes are not tracked in this version.	C Henley
4	Updated Model Design Document to support version 2.0 of the model to incorporate 63 MCRs. The implementation of the MCRs were required to incorporate the 2+2 melter configuration, Waste Compliance Plan, Sample Analysis Plan, and update the Dynamic (G2) Model to reflect WTP design. This update comprises a major rewrite (>20 %) and therefore changes have not been tracked.	C Henley
5	<p>Updated to reflect the design and operating logic and parameter changes to the Dynamic (G2) Model Version 2.1. The major changes that affect the WTP chemical processes included:</p> <ol style="list-style-type: none"> 1) removal of the technetium ion exchange system, 2) removal of the technetium eluant recovery system, 3) addition of the cesium fresh resin system, 4) addition of the spent resin disposal system, 5) application of the rectifier model to the cesium nitric acid recovery process, 6) incorporation of the reconciliation data to the CNP evaporator, 7) incorporation of the reconciliation data to the HLW melter. <p>A total of 14 MCRs were implemented.</p>	Y Deng
6	<p>Updated to reflect the as-built design of the Dynamic (G2) Model Version 3.0. The major changes that affect the WTP chemical processes and operating logic included:</p> <ol style="list-style-type: none"> 1) incorporate the Envelope C blending logic in the HLW Lag Storage Process System. 2) Allow batch specific Envelope C reactions in the Ultrafiltration Feed Preparation Vessels. 	Y Deng

- 3) Enable the Ultimate Overflow Vessel in the Plant Wash and Disposal System and the Eluate Contingency Storage Vessel in the Cesium Nitric Acid Recovery Process System.
- 4) Replace the oxide glass formers with mineral glass formers.
- 5) Include ammonia generation reactions in the HLW and LAW melters.
- 6) Include ammonia absorption reactions in the Submerged Bed Scrubbers in the HLW and LAW Offgas Systems.
- 7) Update sampling logic and provide sample composition at the SAP sample points.
- 8) Provide optional model features to store excess LAW feed and recycle from LAW Offgas Systems.
- 9) Update operating parameters.

A total of 13 MCRs were implemented. This update comprises a major rewrite (>20 %) and therefore changes have not been tracked.

- 7 Updated to reflect the as-built design of the Dynamic (G2) Model Version 3.1. Y Deng
The major changes that affect the WTP chemical processes, operating parameters and logic included:

- 1) Allow ultrafilters to operate at variable flux rates.
- 2) Include ultrafiltration solid heel ejection (PJM related).
- 3) Add the capability of performing oxalate liquid/solid phase equilibrium mass transfers in UFPVs and UFVs if oxalate is supplied in the ORP feed vector.
- 4) Update Cesium Nitric Acid Recovery Evaporator boil-off chemistry.
- 5) Adjust water contents at the LAW MFPVs to address rheology concerns.
- 6) Include dust control water for glass former hoppers.
- 7) Incorporate logic that restricts concentration of lithium in the LAW glass to limit corrosion of melter refractories.
- 8) Incorporate logic that limits the amount of sulfate in the LAW glass to that seen in pilot runs.
- 9) Incorporate HLW Glass Property Model that is based on HLW glass formulation developed by Vitreous State Laboratory for various tank wastes.
- 10) Incorporate HLW glass crystallization/liquidus models that adjust glass formers according to nepheline, spinel, and zirconium liquidus/ crystallization temperatures in the glass.
- 11) Include ultrafiltration recirculation loop flush.
- 12) Perform cesium ion exchange removal operation using overall removal efficiency control.
- 13) Improve operating logic and setpoint control for LAW Concentrate Receipt Process System and LAW Feed Process System.
- 14) Replace urea with ammonia for NOx reduction reactions in Catalytic Oxidizer Reducer.
- 15) Incorporate logic to meet Technical Specification TS-1.1, "Minimum Component Limits in HLW Glass" when the minimum silica (and glass former) concentration in the glass is also met.
- 16) Improve operating logic and setpoint control for HLW Concentrate Receipt Process System and HLW Feed Process System.
- 17) Reroute Waste Neutralization Vessel to HLW Acidic Waste Storage Vessel.
- 18) Update isotope molecular weight values.

- 19) Update line flush volumes for vitrification systems.
- 20) Update HLW melter decontamination factor for sulfate.
- 21) Update HLW Lag Storage Vessel set volume when transition from commissioning to operation.
- 22) Apply vacuum eductor steam condensation to Treated LAW Evaporator Condensate Vessel when dual pumping to the Treated LAW Evaporator occurs.
- 23) Improve model efficiency including model maintainability, input flexibility, database initialization and configuration control, and data output.

This update comprises a major rewrite (more than 20 %) and therefore changes have not been tracked.

- 8 Updated to reflect the as-built design of the Dynamic (G2) Flowsheet Version 4.0. The major changes that affect the WTP chemical processes, operating parameters and logic included: Y Deng

- 1) Change the Envelope C transuranic waste precipitation reactions to include actinides and birnessite.
- 2) Allow viscosity dependent variable flux rates through ultrafilters.
- 3) Apply variable caustic volume for leaching, feed forward leachate to the Ultrafiltration Permeate Collection Vessels.
- 4) Update cooling time after caustic leach in ultrafiltration.
- 5) Apply variable volumes for solid wash and add dilution capabilities to the Ultrafiltration Permeate Collection Vessels.
- 6) Add aluminum liquid/solid phase equilibrium capabilities in various Pretreatment vessels.
- 7) Expand oxalate liquid/solid phase equilibrium capabilities in various Pretreatment vessels.
- 8) Add blending logic for PWD-VSL-0044 and PWD-VSL-0015/0016 streams to produce evaporator concentrate of SpG 1.27 and/or solids concentration less than 8.0 percent.
- 9) Enable evaporator FEP-SEP-00001B.
- 10) Route Envelope C through the FEP evaporator.
- 11) Add capabilities and switches to enable/disable ultrafilter caustic/acid cleaning, loop drain, and heel ejection.
- 12) Add capabilities to perform sequential and/or concurrent oxidative leaching.
- 13) Remove HLW Concentrate Receipt Vessels and revise HLW Melter Feed Preparation Vessel operating logic.
- 14) Include mineral impurities in glass former oxides.
- 15) Add viscosity constraints to the HLW glass model calculations.
- 16) Include glass former oxides and mineral impurities (the metal equivalent) to splits to SBS from melters.
- 17) Add iodine vaporization reaction in melters.
- 18) Allow variable NH₃ gas productions in LAW and HLW melters so that near neutral solutions are achieved in LAW/HLW SBS Condensate Vessels.
- 19) Allow water to be vaporized or condensed in SBS, WESP, HEME, and Caustic Scrubber depending on moisture contents in the inlet.
- 20) Allow tritium and peroxide to follow water in SBS, WESP, HEME, and Caustic Scrubber.
- 21) Add acetonitrile and PCB production reactions in melters and C₂H₃N and

- C12H4Cl6 phase change and destruction reactions in the offgas systems and Pretreatment Vessel Vent Process System. Also splits applicable equipment.
- 22) Update splits and chemical reactions in LAW melters, LAW Melter Offgas Treatment Process System, and LAW Secondary Offgas/Vessel Process System.
 - 23) Update splits and chemical reactions in HLW melters and HLW Melter Offgas Treatment Process System.
 - 24) Update operating logic, SpG and pH controls at the LAW Caustic Scrubber and the Caustic Collection Vessel.
 - 25) Add halogen gas removal reactions to the HOP Silver Mordenite.
 - 26) Update sample locations and hold times.
 - 27) Add PJM/RFD dynamic air usage capabilities.
 - 28) Include chloride impurity in all the caustic soda chemical reagents.
 - 29) Allow waste sodium, process sodium, waste manganese, and process manganese to be tracked separately throughout the flowsheet. This includes the update of all calculations where Na⁺ and Mn⁺⁴ are used prior to the component list expansion, the addition of split factors where they are applicable, and the change of caustic soda reagents from NaOH to Na₂CO₃ (except the caustic for leaching).
 - 30) Update miscellaneous operating parameters in the LAW vitrification systems including line flush volumes, vessel volumes, and vessel vent air flowrates.
 - 31) Update vessel vent air flowrates in the HLW vitrification systems.

In addition, several model perfection changes such as model maintainability, input flexibility, database initialization and configuration control, and data output were included:

- 32) Expand the flowsheet component lists (liquid, solid, oxide, gas) to include components that support additional chemical reactions. Glass former array and mineral array are replaced by the oxide array.
- 33) Develop a Visual Basic program that populates the new components in feed vector provided by the Tank Farm Contractor. This ensures the Tank Farm Contractor Operation and Utilization Plan is usable by the Dynamic (G2) Flowsheet.
- 34) Upgrade Oracle/MatLab post model run data processing utilities to accompany the expanded components.
- 35) Apply a customized coding technique to the Ultrafiltration Task Team related model changes that improves code reusability.

This update comprises a major rewrite (more than 20 %) and therefore changes have not been tracked.

9	Updated to reflect the as-built design of the Dynamic (G2) Flowsheet Version 4.1. The major changes that affect the WTP chemical processes, operating parameters and logic included: 1) Allow ultrafiltration trains to operate in parallel. 2) Update HLW Canister Decontamination Handling System operating logic. 3) Add dilution air to anhydrous ammonia streams connecting to HLW and LAW NO_x scrubbers. 4) Update vessel volumes and maximum flowrates. 5) Modify HLW glass chemistry shell coefficients.	Y Deng

- 6) Apply a new LAW glass chemistry shell.
 - 7) Update Envelope C reaction cooling time.
 - 8)
- 10 Updated to reflect the as-built design of the Dynamic (G2) Flowsheet Version 5.0. Major changes that affect the WTP chemical processes, operating parameters and logic included: Y Deng
- 1) Perform caustic leach in UFP-VSL-00001A/B.
 - 2) Apply ion exchange chemistry models based on Spherical Resorcinol-Formaldehyde resin.
 - 3) Add Glass Former Facility submodel.
 - 4) Include end of mission waste handling operations.
 - 5) Update line flushes for sampling, HPAV, and plugging.
 - 6) Calculate hydrogen generation rates at vessels of interests.
 - 7) Perform pH neutralization reactions for CNP evaporator bottoms.
 - 8) Add rheology water for HLW feeds.
 - 9) Add HEPAs to LVP and HOP.
 - 10) Reroute PJV HEPA and add HLW PJV stack.
 - 11) Update oxalate and aluminum solubility equations.
 - 12) Update ultrafiltration variable flux rate equations.
 - 13) Update sample hold time and locations.
 - 14) Update vessel volumes and pump flows.
 - 15) Update DFs and associated chemical reactions.
 - 16) Add G2MBC.
- Thirty three 33 MCRs have been incorporated. This version update comprises a major rewrite (more than 20 %) and therefore change bars were not provided.
- 11 Updated to reflect the as-built design of the Dynamic (G2) Flowsheet Version 6.0. Major changes that affect the WTP equipment configuration, chemical processes, operating parameters and logic included: Y Deng
- 1) Remove PJV-VSL-00002.
 - 2) Swap CXP-VSL-00001 and CNP-VSL-00003.
 - 3) Combine UFP-VSL-00062A/B/C and CNP-VSL-00003.
 - 4) Combine SBS columns with SBS condensate vessels in LOP and HOP.
 - 5) Apply operating volumes to FEP-SEP-00001A/B and TLP-SEP-00001 evaporators.
 - 6) Add process antifoam agent.
 - 7) Add phosphate solubility.
 - 8) Add caustic operation during solid wash.
 - 9) Add IXC resin outlet flush operations.
 - 10) Add fluid displacement operation during resin regeneration.
 - 11) Incorporate caustic leach decision logic.
 - 12) Incorporate oxidative leach decision logic.
 - 13) Incorporate wash forward/backward decision logic.
 - 14) Incorporate HLW Glass Shell Version 2.0.
 - 15) Apply secular equilibrium for mBa-137 and Y-90.
 - 16) Update DFs, lineflushes, volumes, flowrates, and other operating parameters in various systems.

17) Update G2MBC, Oracle tables, and MatLab scripts.

A total of 26 MCRs have been incorporated. Significant details have also been added to this document which comprises more than 20 % rewrites and therefore change bars were not provided.

12 Updated to reflect the as-built design of the Dynamic (G2) Flowsheet Version 7.0. Major changes that affect the WTP equipment configuration, chemical processes, operating parameters and logic included: Y Deng

- 1) Add CXP guard filter.
- 2) Add IXC backflow operations.
- 3) Add UFP2 double batching operations.
- 4) Add flowsheet option for boehmite leaching.
- 5) Add vessel heel dilution and clean out operations.
- 6) Update CNP evaporator bottoms transfer, storage, neutralization, mixing, and cooling operations.
- 7) Update fresh resin preparation operations.
- 8) Update volumes, flowrates, and sample hold times.
- 9) Update LAW and HLW melter DFs.
- 10) Update phosphate solubility correlation.
- 11) Apply SpG and wt% solid dual controls to FEP and TLP evaporators.
- 12) Model fate of mercury with composition dependent DFs.
- 13) Model fate of semi-volatiles with reactions and splits.
- 14) Add end of mission summary outputs.
- 15) Update Oracle/MatLab scripts and G2MBC.

A total of 20 MCRs have been incorporated. The document is updated to use the latest WTP template.

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Acronyms

AES	Aspen Engineering Suite
AFA	Antifoaming Agent
ASCII	American Standard Code for Information Interchange
BARD	Flowsheet Bases, Assumptions, and Requirements Document
BMP	Bitmap File Format
BOF	Balance of Facilities
CF	Conversion Factor
CNP	Cesium Nitric Acid Recovery
CRP	Cesium Resin Addition
CRV	Concentrate Receipt Vessel
CSV	Comma Separated Value File Format
CXP	Cesium Ion Exchange Process System
CV	Column Volume
DF	Decontamination Factor
DIW	Demineralized Water
DOE	U.S. Department of Energy
DPPG	Decomposed Polypropylene Glycol
DPDMS	Decomposed Polydimethylsiloxane
EFRT	External Flowsheet Review Team
ETF	Effluent Treatment Facility
FEP	Waste Feed Evaporation Process
FRP	Waste Feed Receipt Process System
G2	Gensym G2 Bundle Version 8.1
G2MBC	G2 Mass Balance Calculator
GFR	Glass Formers Reagent System
GUI	Graphical User Interface
HDH	HLW Canister Decontamination Handling System
HEME	High Efficiency Mist Eliminator
HEPA	High Efficiency Particular Air Filter
HFP	HLW Melter Feed Process System
HGR	Hydrogen Generation Rate
HLP	HLW Lag Storage and Feed Blending Process System
HLW	High-Level Waste
HMP	HLW Melter Process System
HOP	HLW Melter Offgas Treatment Process System
HPAV	Hydrogen in Piping and Ancillary Vessels
ICD	Interface Control Document
IHLW	Immobilized High-Level Waste
ILAW	Immobilized Low-Activity Waste
ISARD	Integrated Sampling Analysis Requirements Document
IX	Ion Exchange
IXC	Ion Exchange Column
JPEG	Joint Photographic Experts Group File Format
KB	Knowledge Base
LAW	Low-Activity Waste
LCP	LAW Concentrate Receipt Process System

LERF	Liquid Effluent Retention Facility
LFP	LAW Feed Preparation Process System
LMP	LAW Melter Process System
LOP	LAW Melter Offgas Treatment Process System
LVP	LAW Secondary Offgas/Vessel Process System
MCR	Model Change Request
MDD	Model Design Document
MDI	Multiple Document Interface
MRQ	Model Run Request
MFPV	Melter Feed Preparation Vessel
MFV	Melter Feed Vessel
NAPLs	Non-Aqueous Phase Liquids
ODBC	Open Database Connectivity
ORP	Office of River Protection
PCB	polychlorinated biphenyl
PDMS	Polydimethoxysiloxane
PE	Process Engineering
PJM	Pulse Jet Mixer
PJV	Pulse Jet Ventilation
PPG	Polypropyleneglycol
PVP	Pretreatment Vessel Vent Process
PWD	Plant Wash and Disposal System
RF	Spherical Resorcinol-Formaldehyde Resin
RDP	Spent Resin Collection and Dewatering Process System
RFD	Reverse Flow Diverter
RLD	Radioactive Liquid Waste Disposal System
SBS	Submerged Bed Scrubber
SDO	Supplemental Data Outputs
SP6	TFC System Plan Revision 6 Feed Vector
SpG	Specific Gravity
STRN	Stream Number
TCP	Treated LAW Concentrate Storage Process System
TFC	Tank Farm Contractor
TLP	Treated LAW Evaporation Process System
TOC	Total Organic Carbon
TPA	Tri-Party Agreement
TRU	Transuranic Wastes
TUA	Tank Utilization Assessment
TXT	Text File Format
UFP	Ultrafiltration Process System
UFP1	Ultrafiltration Feed Preparation Vessel
UFP2	Ultrafiltration Feed Vessel
V&V	Verification and Validation
WESP	Wet Electrostatic Precipitator
WITNESS	Lanner Group WITNESS
WT%	Weight Percent
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1 Introduction

The Hanford Tank Waste Treatment and Immobilization Plant (WTP) Statement of Work (Department of Energy Contract DE-AC27-01RV14136, Section C) requires the contractor to develop and use process models for flowsheet analyses and pre-operational planning assessments. The Dynamic (G2) Flowsheet is a discrete-time process model that enables the project to evaluate impacts to throughput from event-driven activities such as pumping, sampling, storage, recycle, separation, and chemical reactions. The model is developed by the Process Engineering (PE) department, and is based on the *Flowsheet Bases, Assumptions, and Requirements* Document (24590-WTP-RPT-PT-02-005), commonly called the *BARD*. The terminologies of Dynamic (G2) Flowsheet and Dynamic (G2) Model are interchangeable in this document.

The foundation of this model is a dynamic material balance governed by prescribed initial conditions, boundary conditions, and operating logic. The dynamic material balance is achieved by tracking the storage and material flows within the plant as time increments. The initial conditions include a feed vector that represents the waste compositions and delivery sequence of the Tank Farm batches, and volumes and concentrations of solutions in process equipment before startup. The boundary conditions are the physical limits of the flowsheet design, such as piping, volumes, flowrates, operation efficiencies, and physical and chemical environments that impact separations, phase equilibriums, and reaction extents. The operating logic represents the rules and strategies of running the plant.

The Dynamic (G2) Model is developed using the object-oriented programming platform of G2 (Gensym G2 Bundle Version 8.1). Equipment, unit operations, systems, and their connections are represented by objects graphically and are organized in knowledge base (KB) workspaces. Programming techniques such as modularization, class hierarchy and inheritance, encapsulation and information hiding, multi-thread and parallel computing, and process synchronization are utilized. Interprocess connectivity between Microsoft Access to/from G2, and G2 to Oracle databases, are enabled through Open Database Connectivity (ODBC) and G2-Oracle bridge products. Animations with layered and vector-based graphics are programmed for visualization of the plant operation. Graphical user interfaces (GUIs) including pull-down/pop-up menus, spreadsheet input/output, selection/type-in boxes, and action buttons are also provided.

The baseline version of the Dynamic (G2) Flowsheet contains input parameters such as vessel volumes, flowrates, sample hold times, chemical reactions and conversion factors (CFs), separation coefficients, feed vector, hot commissioning, hot operation, and ramp-up dates with their associated glass production rates. This baseline flowsheet is modified for scenario studies initiated by Model Run Requests (MRQs). Scenario runs could be as simple as a change to an input parameter listed above or as complicated as reconfiguring an entire unit operation/system.

Model runs can be performed for specific feed vector batches or for the entire feed vector. Under the PE's computing environment (24590-WTP-PL-TE-01-008, *System Design for Process Modeling*), a typical model run for an entire feed vector with full data collection will take up to 24 hours to complete and more than 10 gigabytes of data could be recorded in the Oracle databases. Automation tools such as MatLab scripts and Visual C# programs are used to convert the Oracle data to more easily understandable tables and charts.

Results of model runs generally include:

- 1) Feed vector batch required delivery dates
- 2) WTP simulation duration
- 3) Low-activity waste (LAW) glass container count and high-level waste (HLW) glass canister count
- 4) Volumes and compositions of treated LAW to the Supplemental LAW Facility
- 5) Volumes and compositions of WTP effluent to Liquid Effluent Retention Facility (LERF) and Effluent Treatment Facility (ETF)
- 6) Ultrafiltration Feed Preparation Vessel (UFP1) cycle time and associated operating parameters
- 7) Ultrafiltration Feed Vessel (UFP2) cycle time and associated operating parameters
- 8) Solubility constituent mass distribution diagrams
- 9) Solid wash and oxidative wash volumes
- 10) Caustic volumes for leaching and aluminum solubility
- 11) Volume history data for key process vessels
- 12) Sodium molarity and weight percent (wt %) solids for key process vessels
- 13) Totalized mass transfer for every process stream
- 14) Waste loading of LAW and HLW glasses
- 15) Evaporator concentrate data including sodium molarity and Specific Gravity (SpG)
- 16) Sample composition data at the *Integrated Sampling and Analysis Requirements Document (ISARD)* (24590-WTP-PL-PR-04-0001) locations and other locations of interests
- 17) Chemical reagent, process condensate, and demineralized water (DIW) consumption
- 18) Mineral glass former utilization
- 19) Mass balance of key species through the WTP

The *2010 WTP Tank Utilization Assessment* (24590-WTP-RPT-PET-10-020) provides some comprehensive flowsheet analyses using the data described.

2 Purpose

Model Change Requests (MCRs) established by the PE department were incorporated in Version 7.0 of the Dynamic (G2) Flowsheet to: address the External Flowsheet Review Team (EFRT) issue resolutions and WTP's design evolution, align with research and technology results, and improve model fidelity, functionality, and performance. The MCRs were implemented based on the baseline Dynamic (G2) Flowsheet Version 6.0 released on August 17, 2010. Specific tasks that the Dynamic (G2) Flowsheet Version 7.0 supports include:

- 1) DOE Deliverable 2.6 - Tank Utilization Assessment (TUA)
 - a) Analyze Pretreatment and Vittrification performance
 - b) Analyze recycles and byproducts
 - c) Analyze LAW and HLW glass production and identify downtime due to Pretreatment and/or Glass Former Facility
 - d) Analyze sodium chemical additions
 - e) Analyze feed sequence and volume of waste received based on the feed vector

- f) Analyze effluent generation and distribution
 - g) Analyze variability of LAW and HLW vitrification feed and glass formulations
- 2) Tri-Party Agreement (TPA) Milestone M-062-049 (24590-WTP-RPT-PE-11-008)
 - a) Demonstrate WTP design capacity
- 3) Dynamic Flowsheet Developments
 - a) Evaluate process control strategies
 - b) Evaluate mixing uncertainties
 - c) Evaluate leaching kinetics
 - d) Evaluate design change alternatives
 - e) Evaluate hot commissioning alternatives
 - f) Evaluate Supplemental LAW Facility impacts

The WTP procedure *Lifecycle Control of Process Models* (24590-WTP-GPP-PT-013) requires that the dynamic flowsheet be summarized in a Model Design Document (MDD). The purpose of this document is to capture and describe the as-built design of the G2 model for Version 7.0. The *Lifecycle Control of Process Models* also stipulates that the model will undergo Verification and Validation (V&V). The V&V activities are specified in the *Dynamic (G2) Flowsheet Version 7.0 Test Plan* (24590-WTP-TP-PE-11-001) and results are published in the *Dynamic (G2) Flowsheet Version 7.0 Verification and Validation Report* (24590-WTP-VV-PE-11-001).

3 Model Basis and References

The PE department has strategically applied the *BARD* as the basis for the development of process models, including the Steady-State Flowsheet (AES), Dynamic (G2) Flowsheet, and the WTP Operations Research (WITNESS) Flowsheet. The *BARD* provides the descriptions of plant layout, physical connections, systems, and unit operations and their design and operating parameters, governing equations, physical and chemical environment and reactions, and control logic that serve as the single-source reference for all the process models. The technical contents presented in this MDD are the implementation of the *BARD* in the Dynamic (G2) Flowsheet Version 7.0.

4 Model System Descriptions

4.1 Time Steps and Dynamic Material Balance

The Dynamic (G2) Model performs discrete-time material balance calculations over the WTP based on prescribed initial conditions, boundary conditions, and operating logic. The time steps are small enough to preserve the resolution of plant operations and large enough to avoid unacceptably long model run time. A 6-minute time step (i.e., every simulation clock tick represents 1/10 of a simulated hour) is applied to the entire model except the Glass Former Reagent (GFR) System where a 1-minute time step (every clock tick represents 1/60 of a simulated hour) is utilized. The 1-minute time step in the GFR is needed due to the large flowrates and small sizes of its equipment.

Material balance is achieved by tracking the storage, pumping, separation, reaction, and phase change of chemical components in every unit operation over each time increment. Each unit operation is event driven as the status of that unit operation changes from time to time. An analyzer logic procedure controls the actions of each unit operation using pump procedures, reaction procedures, sample procedures, or other action procedures as appropriate depending on the current status of that unit operation. The simulation clocks are used to synchronize the actions of all the processes.

4.2 Feed Vector

The Dynamic (G2) Model processes a feed vector that is created by the Tank Farm Contractor (TFC) and provided by DOE-WTP. The feed vector consists of a waste quantity file and a leach factor file. The waste quantity file contains the batch names, proposed delivery dates, envelope types of the batches, and the quantities of liquid and solid components (in units of kg-moles) of the Hanford Tank Farm wastes. The leach factor file contains the leach factors for the constituents that will be leached out in the UFP2 vessels. Currently ten solid constituents, including Al^{+3} , Bi^{+3} , Ca^{+2} , $\text{Cr}(\text{Total})$, Fe^{+3} , Na^+ , PO_4^{-3} , Si^{+4} , U (all isotopes), and SO_4^{-2} , are leached in the Dynamic (G2) Model (Note: leach factors for Al^{+3} and PO_4^{-3} are not used in the model as the leaching of $\text{Al}(\text{OH})_3$ and “soft” PO_4^{-3} is driven by solubility correlations).

PE department personnel modify the TFC feed vectors to form components specific to the WTP operations. These components must be added to the feed vector arrays before the feeds enter the plant (Table I-1). Typically the components are created in a manner that maintains the feed vector’s charge balance. Another modification to the TFC feed vector is the following application of secular equilibrium rules for 137m-Ba and 90-Y (kg-moles):

$$137\text{m-Ba} = 1.526\text{e-}7 * 137\text{-Cs} \quad (\text{Eq. 1})$$

$$90\text{-Y} = 2.54\text{e-}4 * 90\text{-Sr} \quad (\text{Eq. 2})$$

Appendix I further discusses the details of these feed vector operations.

After modifications have been made to the TFC feed vector, it is imported to the G2 model from an Access database through the ODBC bridge and is saved as part of the MRQ specific KB files. The feed vectors are updated periodically as a result of DOE-WTP studies intended to optimize the operations at both the Tank Farm, and the WTP, or as the result of other studies. The default in the Dynamic (G2) Model Version 7.0 is the TFC System Plan Revision 6 (SP6) Case 1 feed vector supplied by ORP.

4.3 Equipment Initialization

Some equipment must be filled with chemical reagents before they can be utilized. These include:

- 1) Ultrafiltration post-isolation valve pipes (UFP-02A-P2, UFP-02B-P2)
- 2) Cesium Reagent Vessel (CXP-VSL-00005)
- 3) Cesium Ion Exchange (CXP) Columns (CXP-IXC-00001/2/3/4)
- 4) Cesium Nitric Acid Recovery (CNP) Evaporator (CNP-EVAP-00001)
- 5) Cesium Resin Addition (CRP) Vessel (CRP-VSL-00001)
- 6) Recovered Nitric Acid Vessel (CNP-VSL-00004)
- 7) Spent Resin Slurry Vessel (RDP-VSL-00002A)
- 8) LAW Submerged Bed Scrubbers (SBS) (LOP-SCB-00001/2)

- 9) HLW SBS (HOP-SCB-00001/2)
- 10) Vessel Vent Caustic Scrubber (PVP-SCB-00002)
- 11) Silica Storage Silo (GFR-TK-00001)
- 12) Zinc Oxide Storage Silo (GFR-TK-00002)
- 13) Titanium Dioxide Storage Silo (GFR-TK-00003)
- 14) Ferric Oxide Storage Silo (GFR-TK-00004)
- 15) Zirconium Silicate Sand Storage Silo (GFR-TK-00005)
- 16) Lithium Carbonate Storage Silo (GFR-TK-00006)
- 17) Boric Acid Storage Silo (GFR-TK-00007)
- 18) Aluminum Silicate Storage Silo (GFR-TK-00008)
- 19) Magnesium Silicate Storage Silo (GFR-TK-00009)
- 20) Calcium Silicate Storage Silo (GFR-TK-00010)
- 21) Sucrose Storage Silo (GFR-TK-00011)
- 22) Sodium Carbonate Storage Silo (GFR-TK-00012)
- 23) Borax Storage Silo (GFR-TK-00028)
- 24) Balance of Facilities (BOF)

Reagents for the WTP chemical processes are assumed to be readily available in the BOF before startup. Reagent types, volumes, and concentrations of the BOF utilized in the G2 model are presented in Appendix B. Reagent types, volumes, and concentrations added to the equipment listed above during model initialization are discussed in related sub-sections under Section 4.8.

4.4 Component Lists

The Dynamic (G2) Model utilizes four component lists for material balance calculations. These component lists and the associated number of constituents are given in Table 1.

Table 1 Component Lists and Lengths

Component List	Number of Constituents
Liquid	162
Solid	162
Gas	16
Oxide	73

Appendix A presents the symbols, names, and molecular weights of these components. Radionuclides are tracked as liquid and solid components.

4.5 Equipment Classes

G2 is an object-oriented programming platform and each piece of WTP equipment is represented by a graphical object in the model (see figures in Appendix F for illustrations). Each object is an instance of an equipment class that is created according to the equipment's characteristics and functionalities. Characteristics of an equipment class are implemented as attributes that represent the physical limits, control parameters, operating status, and contents of the equipment, while functionalities of an equipment class are implemented as methods that dictate what the equipment will do. Examples of characteristics are vessel volumes, pump rates, sample times, masses of various phases, pumping and receiving status,

and others. Examples of functionalities include pumping, sampling, reacting, and others. Equipment of the same class possesses identical attributes and perform similar tasks. Figure 1 shows a WTP equipment class hierarchy where the parent-child relationships are presented. Major WTP equipment and associated equipment classes and component lists are given in Table 2.

Figure 1 WTP Equipment Class Hierarchy

Table 2 Equipment Classes and Associated Component Lists

Equipment Name	Equipment Class	Component Lists
CNP-DISTC-00001	f-split-2-column	liquid, solid
CNP-EVAP-00001	batch-evaporator	liquid, solid
CNP-VSL-00003	mixer-6-outputs	liquid, solid, gas
CNP-VSL-00004	mixer-6-outputs	liquid, solid, gas
CRP-VSL-00001	mixer-6-outputs	liquid, solid, gas
CXP-FILT-00001	filter	liquid, solid
CXP-IXC-00001	ix-column	liquid, solid
CXP-IXC-00002	ix-column	liquid, solid
CXP-IXC-00003	ix-column	liquid, solid
CXP-IXC-00004	ix-column	liquid, solid
CXP-VSL-00004	mixer-6-outputs	liquid, solid, gas
CXP-VSL-00026A	mixer	liquid, solid, gas
CXP-VSL-00026B	mixer	liquid, solid, gas
CXP-VSL-00026C	mixer	liquid, solid, gas
ETF-1	mixer-6-outputs	liquid, solid, gas
FEP-DMST-00001A	evaporator-condenser-tank	liquid, solid, gas
FEP-DMST-00001B	evaporator-condenser-tank	liquid, solid, gas
FEP-SEP-00001A	split-evaporator	liquid, solid
FEP-SEP-00001B	split-evaporator	liquid, solid
FEP-VSL-00005A	mixer-6-outputs	liquid, solid, gas
FEP-VSL-00005B	mixer-6-outputs	liquid, solid, gas
FEP-VSL-00017A	mixer	liquid, solid, gas
FEP-VSL-00017B	mixer	liquid, solid, gas
FRP-VSL-00002A	mixer-6-outputs	liquid, solid, gas
FRP-VSL-00002B	mixer-6-outputs	liquid, solid, gas
FRP-VSL-00002C	mixer-6-outputs	liquid, solid, gas
FRP-VSL-00002D	mixer-6-outputs	liquid, solid, gas
GFR-TK-00001	silo	oxide
GFR-TK-00002	silo	oxide
GFR-TK-00003	silo	oxide
GFR-TK-00004	silo	oxide
GFR-TK-00005	silo	oxide
GFR-TK-00006	silo	oxide
GFR-TK-00007	silo	oxide
GFR-TK-00008	silo	oxide
GFR-TK-00009	silo	oxide
GFR-TK-00010	silo	oxide
GFR-TK-00011	silo	oxide
GFR-TK-00012	silo	oxide
GFR-TK-00013	silo	oxide
GFR-TK-00014	silo	oxide
GFR-TK-00015	silo	oxide
GFR-TK-00016	silo	oxide
GFR-TK-00018	silo	oxide
GFR-TK-00019	silo	oxide

Equipment Name	Equipment Class	Component Lists
GFR-TK-00021	silo	oxide
GFR-TK-00022	glass-former-mixer	liquid, oxide
GFR-TK-00023	glass-former-mixer	liquid, oxide
GFR-TK-00025	glass-former-mixer	liquid, oxide
GFR-TK-00028	silo	oxide
GFR-TK-00031	glass-former-mixer	liquid, oxide
GFR-VSL-00002	transporter	oxide
GFR-VSL-00003	transporter	oxide
GFR-VSL-00004	transporter	oxide
GFR-VSL-00005	transporter	oxide
GFR-VSL-00006	transporter	oxide
GFR-VSL-00007	transporter	oxide
GFR-VSL-00008	transporter	oxide
HDH-TTBL-00001	canister-cooling-rack	none
HDH-VSL-00001	mixer	liquid, solid, gas
HDH-VSL-00002	mixer	liquid, solid, gas
HDH-VSL-00003	mixer	liquid, solid, gas
HDH-VSL-00004	mixer	liquid, solid, gas
HFP-VSL-00001	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HFP-VSL-00002	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HFP-VSL-00005	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HFP-VSL-00006	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HLP-VSL-00022	mixer-6-outputs	liquid, solid, gas
HLP-VSL-00027A	mixer-6-outputs	liquid, solid, gas
HLP-VSL-00027B	mixer-6-outputs	liquid, solid, gas
HLP-VSL-00028	mixer-6-outputs	liquid, solid, gas
HLW-CANISTER-COOLING-RACK	canister-cooling-rack	none
HLW-CANISTERS-1	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HLW-CANISTERS-2	mixer-oxide-glass-formers	liquid, solid, gas, oxide
HLW-PJV-STACK	stack	liquid, solid, gas
HLW-STACK	stack	liquid, solid, gas
HMP-MLTR-00001	glass-melter	liquid, solid, gas, oxide
HMP-MLTR-00002	glass-melter	liquid, solid, gas, oxide
HOP-ABS-00002	accumulation-scrubber	liquid, solid, gas
HOP-ABS-00003	accumulation-scrubber	liquid, solid, gas
HOP-ADBR-00001AB	accumulation-scrubber	liquid, solid, gas
HOP-ADBR-00002AB	accumulation-scrubber	liquid, solid, gas
HOP-HEME-00001	liquid-scrubber	liquid, solid, gas
HOP-HEME-00002	liquid-scrubber	liquid, solid, gas
HOP-HEPA-00001-2-AB	accumulation-scrubber	liquid, solid, gas
HOP-HEPA-00007-8-AB	accumulation-scrubber	liquid, solid, gas
HOP-SCB-00001	sbs-scrubber	liquid, solid, gas
HOP-SCB-00002	sbs-scrubber	liquid, solid, gas
HOP-SCR-00001	accumulation-scrubber	liquid, solid, gas
HOP-SCR-00002	accumulation-scrubber	liquid, solid, gas
HOP-VSL-00903	sbs-condensate-receiver	liquid, solid, gas

Equipment Name	Equipment Class	Component Lists
HOP-VSL-00904	sbs-condensate-receiver	liquid, solid, gas
HOP-WESP-00001	liquid-scrubber	liquid, solid, gas
HOP-WESP-00002	liquid-scrubber	liquid, solid, gas
IHLW1	hot-canister	liquid, solid, oxide
IHLW2	hot-canister	liquid, solid, oxide
ILAW1	hot-canister	liquid, solid, oxide
ILAW2	hot-canister	liquid, solid, oxide
LAW-CONTAINERS-1	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LAW-CONTAINERS-2	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LAW-STACK	stack	liquid, solid, gas
LCP-VSL-00001	mixer-6-outputs	liquid, solid, gas
LCP-VSL-00002	mixer-6-outputs	liquid, solid, gas
LFP-VSL-00001	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LFP-VSL-00002	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LFP-VSL-00003	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LFP-VSL-00004	mixer-oxide-glass-formers	liquid, solid, gas, oxide
LMP-MLTR-00001	glass-melter	liquid, solid, gas, oxide
LMP-MLTR-00002	glass-melter	liquid, solid, gas, oxide
LOP-SCB-00001	sbs-scrubber	liquid, solid, gas
LOP-SCB-00002	sbs-scrubber	liquid, solid, gas
LOP-VSL-00001	sbs-condensate-receiver	liquid, solid, gas
LOP-VSL-00002	sbs-condensate-receiver	liquid, solid, gas
LOP-WESP-00001	liquid-scrubber	liquid, solid, gas
LOP-WESP-00002	liquid-scrubber	liquid, solid, gas
LVP-ADBR-00001AB	accumulation-scrubber	liquid, solid, gas
LVP-HEPA-00001AB	accumulation-scrubber	liquid, solid, gas
LVP-SCB-00001	liquid-scrubber	liquid, solid, gas
LVP-SCR-00001-2	accumulation-scrubber	liquid, solid, gas
LVP-TK-00001	mixer	liquid, solid, gas
PJM-RFD-VENT	accumulation-scrubber	liquid, solid, gas
PJV-HEPA	accumulation-scrubber	liquid, solid, gas
PJV-HEPA-00004-5	accumulation-scrubber	liquid, solid, gas
PJV-VSL-00001	liquid-scrubber	liquid, solid, gas
PVP-ABS-00001AB	accumulation-scrubber	liquid, solid, gas
PVP-HEME-00001	liquid-scrubber	liquid, solid, gas
PVP-HEPA-00001-2	accumulation-scrubber	liquid, solid, gas
PVP-OXID-00001	accumulation-scrubber	liquid, solid, gas
PVP-SCB-00002	sbs-condensate-receiver	liquid, solid, gas
PVP-STACK	stack	liquid, solid, gas
PVP-VSL-00001	evaporator-condenser-tank	liquid, solid, gas
PWD-VSL-00015	mixer-6-outputs	liquid, solid, gas
PWD-VSL-00016	mixer-6-outputs	liquid, solid, gas
PWD-VSL-00033	mixer-6-outputs	liquid, solid, gas
PWD-VSL-00043	mixer-6-outputs	liquid, solid, gas
PWD-VSL-00044	mixer-6-outputs	liquid, solid, gas
RDP-VSL-00002A	mixer-6-outputs	liquid, solid, gas

Equipment Name	Equipment Class	Component Lists
RDP-VSL-00002B	mixer-6-outputs	liquid, solid, gas
RDP-VSL-00002C	mixer-6-outputs	liquid, solid, gas
RESIN-DISPOSAL	mixer-6-outputs	liquid, solid, gas
RLD-TK-00006A	mixer-6-outputs	liquid, solid, gas
RLD-TK-00006B	mixer-6-outputs	liquid, solid, gas
RLD-VSL-00003	mixer	liquid, solid, gas
RLD-VSL-00004	mixer	liquid, solid, gas
RLD-VSL-00005	mixer	liquid, solid, gas
RLD-VSL-00007	mixer	liquid, solid, gas
RLD-VSL-00008	mixer	liquid, solid, gas
RLD-VSL-00017A	mixer	liquid, solid, gas
RLD-VSL-00017B	mixer	liquid, solid, gas
SUPPLEMENTAL-LAW-RECYCLE	mixer-6-outputs	liquid, solid, gas
SUPPLEMENTAL-LAW-TREATED	mixer-6-outputs	liquid, solid, gas
TANK-FARM-HLW	mixer-6-outputs	liquid, solid, gas
TANK-FARM-LAW	mixer-6-outputs	liquid, solid, gas
TCP-VSL-00001	mixer-6-outputs	liquid, solid, gas
TLP-DMST-00001	evaporator-condenser-tank	liquid, solid, gas
TLP-SEP-00001	split-evaporator	liquid, solid
TLP-VSL-00002	mixer-6-outputs	liquid, solid, gas
TLP-VSL-00009A	mixer-6-outputs	liquid, solid, gas
TLP-VSL-00009B	mixer-6-outputs	liquid, solid, gas
UFP-02A-P1	pipe-volume	liquid, solid
UFP-02A-P2	pipe-volume	liquid, solid
UFP-02B-P1	pipe-volume	liquid, solid
UFP-02B-P2	pipe-volume	liquid, solid
UFP-VSL-00001A	mixer-6-outputs	liquid, solid, gas
UFP-VSL-00001B	mixer-6-outputs	liquid, solid, gas
UFP-VSL-00002A	mixer-6-outputs	liquid, solid, gas
UFP-VSL-00002B	mixer-6-outputs	liquid, solid, gas
UFP-VSL-00062A	mixer-6-outputs	liquid, solid, gas

4.6 Volume Calculations

The volume of material in a unit operation is calculated by analyzing the amounts and types of components in the unit's component array. In most cases, the total volume involves the partial volumes of liquid and solid, but in some unit operations it also possesses the contribution from oxides. In equipment where oxide exists, its volume is added to the solid volume. Gas components exist in the form of mass in some equipment and do not contribute to the total volume of the equipment.

A liquid's SpG is calculated by summing the mass of all the dissolved constituents in the volume defined for the solution, calculating the weight percent, and then estimating the density from a correlation derived from NaOH and NaNO₃ dissolved in water (Equations 3 and 4). Using the liquid SpG, a volume for the liquid components is obtained.

$$\text{SpG} = 0.00935 X + 0.996 \quad \text{if } X > 0 \quad (\text{Eq. 3}).$$

$$\text{SpG} = 1.0 \quad \text{if } X \leq 0 \quad (\text{Eq. 4})$$

Where:

SpG = specific gravity of a solution (dimensionless)
 $X = \{\sum(\text{liquid}[i]) - \text{liquid}[\text{water}]\} / \sum(\text{liquid}[i]) \times 100$ (dimensionless)
 liquid = liquid components in the solution (kg)
 i = 0 to 161

This SpG correlation applies to every process equipment that requires the calculation of liquid volume except the Cesium Evaporator Separator Vessel (CNP-EVAP-00001), where a ternary correlation of HNO_3 , NaNO_3 , and H_2O is utilized. Details of the CNP-EVAP-00001 SpG correlation are discussed in Section 4.8.5.

The solid and oxide components have constant density values. The overall density for solids is approximated at 3.0 grams per cubic centimeter (g/cm^3). The LAW glass density is set at $2.58 \text{ g}/\text{cm}^3$ while the HLW glass density is set at $2.66 \text{ g}/\text{cm}^3$. Using the constant densities, the volumes of solids and oxides are determined.

4.7 Common Operating Rules

There are operating rules/programming conventions that are used repeatedly throughout the model. The purpose of this section is to document these common operating rules used in the development of the Dynamic (G2) Model so that recurring discussions are not needed for the unit operations. The most prevalent operating rules used in the model are specified in the following subsections.

4.7.1 Basic Model Rules

Components, in kg-moles, are tracked in the model using component arrays. Each unit operation (vessel, evaporator, column, scrubber, melter, condenser, etc.) has its own component arrays which contain the components at that time. When material is transferred out of the unit, the amount of material to be removed in that time step is calculated and subtracted from the arrays of the unit emptying and added to the arrays of the unit filling using a floating-point data type with a 16-digit precision. This ensures a conservation of mass within the model.

Feed-lists and output-lists are used for the determination of batch transfers. When an upstream unit is ready to transfer material out, the unit is placed on its output-list. When a downstream unit is ready to receive material, it is placed on its feed-list. The upstream analyzer logic procedure constantly scans for the status of both lists and triggers the upstream unit pump procedure for pumping when it discovers that both upstream and downstream units are ready. This methodology ensures that unwanted transfers do not occur. Multiple feed-lists and/or output-lists may exist for vessels having multiple inflow sources and/or outflow destinations, respectively.

When the unit transfers material, it transfers a fraction of kg-moles from the component arrays based on the fraction of the unit's volume that needs to be transferred. The fraction is constrained by the pump rate of the upstream unit, the remaining volume of the upstream unit that can be pumped, and the remaining space of the downstream unit that can be filled.

There are exceptions in some vessels where they can be emptied and filled at the same time. There are also exceptions in some vessels where contingency volumes exist such that the vessel can receive if it

needs to and discharge if the downstream unit becomes available. These exceptions are discussed as appropriate in detail in Section 4.8.

4.7.2 Batch Transfers

The batch transfer process is the most commonly used vessel operation in the dynamic model. When the upstream vessel is full or reaches its pre-assigned setpoint, the upstream vessel is placed on its output-list. When the downstream vessel is empty or reaches its minimum volume, the vessel is placed on its input-list. The analyzer logic of the upstream vessel confirms that both vessels are ready. If there are no other conditions or control logic preventing the transfer, the transfer begins and the contents of the upstream vessel are transferred to the downstream vessel. The transfer volume is calculated for each 6-minute, or 1-minute as appropriate, time-step by taking the minimum of the following: the volume available to pump from the upstream vessel, the available space in the downstream vessel, and the capacity of the pump. After each time-step transfer, both the upstream and downstream vessel volumes are updated, along with the vessel component arrays. The volumes of both vessels are checked again and either triggered to continue transferring or triggered to stop transferring because the volume constraints have been met. The batch transfer is terminated when the upstream vessel reaches its minimum volume or the downstream vessel reaches either its setpoint or maximum volume.

Transfer lines do not have volumes in the model so that materials out of the upstream vessels equal to materials into the downstream vessels. However, actual transfer line volumes are used external to the G2 model when line flush volumes are calculated. Line flush volumes are provided in Table H-1.

Exceptions exist for the ultrafiltration filter loops where the transfer lines contain volumes and flushing efficiencies are applied during power flush operations. Section 4.8.3 provides detailed discussions of the ultrafiltration filter loops.

4.7.3 Continuous Transfers

The continuous transfer process is used primarily in the melters, offgas systems, and the evaporators, but is also applied to the UFP-VSL-00002A/B vessels and the “Super Tank” (Note: “Super Tank” is the modeling simplification that combines the functions of UFP-VSL-00062A/B/C and CXP-VSL-00004). When a continuous transfer occurs, material enters the unit operation, reactions and/or splits are performed, and the remaining material exits the unit operation all in one single time step.

Some continuous transfer unit operations can be described as semi-continuous transfer unit operations. This is because they accumulate some of the material that continuously passes through and eventually empty the gathered material in a batch transfer. The Cesium Nitric Acid Recovery Evaporator, Submerged Bed Scrubbers, and Caustic Scrubbers are examples of semi-continuous transfers.

4.7.4 Action Modes of Vessels

Most of the process vessels operate in six action modes, “Empty”, “Fill”, “Filling”, “Sampling”, “Empty-Now”, “Emptying”. Definitions for these action modes are given below:

“Empty” = A vessel is empty or at minimum volume

“Fill” = A vessel is waiting to be filled

“Filling” = A vessel is currently being filled

“Sampling” = A vessel is being sampled

“Empty-Now” = A vessel is waiting to be emptied.

“Emptying” = A vessel is currently being emptied.

The less common operation modes used in the model are not discussed in this MDD but can be obtained from the G2 codes. A vessel can only be filled when it is in the “Empty” or “Fill” modes. Only one source can be pumped into a vessel at a time. Exception exists in some vessels where they can be filled and emptied at the same time. Exception also exists in some vessels where contingency volume is utilized (e.g., a vessel can either be filled or discharged when it is in the contingency zone, depending on the conditions of the upstream or downstream vessels). Contingency volume is discussed in Section 4.7.5. Details of these exceptions are discussed as appropriate in Section 4.8.

4.7.5 Contingency Volume

Some vessels have multiple setpoint controls and contingency volumes. These vessels operate between the minimum and maximum volumes with two setpoints in between. A contingency vessel can be filled, and then continue to be filled until the current batch (after being completely transferred in) raises the volume to or above setpoint #1. The mode of the contingency vessel is then changed to “Continuous”. If the downstream vessel is not ready to receive a transfer, the contingency vessel continues to be filled until the volume is at, or above, setpoint #2, then the mode of the contingency vessel is changed to “Empty-Now”. The contingency volume is set between setpoint #1 and the setpoint #2. The contingency vessel can be emptied any time when it is in the contingency zone and the downstream vessel is available.

The list below provides the names of contingency vessels which are further discussed in Section 4.8 as appropriate.

CNP-VSL-00003
HOP-VSL-000903 (modeled as part of HOP-SCB-00001)
HOP-VSL-000904 (modeled as part of HOP-SCB-00002)
LOP-VSL-00001 (modeled as part of LOP-SCB-00001)
LOP-VSL-00002 (modeled as part of LOP-SCB-00002)
PWD-VSL-00033
PWD-VSL-00043
PWD-VSL-00044
PVP-VSL-00001
TCP-VSL-00001
TLP-VSL-00009A
TLP-VSL-00009B

4.7.6 Chemical Additions

All chemical additions to the processes are done through chem-add objects. A chem-add is normally dedicated to a unit operation and delivers a specific solution of chemicals with a preset concentration. The amount of chemical solution needed is either pre-defined or calculated to achieve the desired concentration of that chemical in the unit. Readers of this document will notice that Nap⁺ and Mnp are used throughout the document. The purpose is to distinguish the process sodium and process manganese added as chemical reagents in the WTP from the waste sodium and waste manganese either received from the feed vector or classified as “waste” in the WTP contract. A detailed discussion of chemical additions is presented in Appendix B.

4.7.7 Neutralization Reactions

When both H^+ and OH^- are present in a vessel, they will react to form H_2O . The reaction occurs just before the unit operation receives chemicals, performs other reactions, or becomes ready for discharge, so it is possible to see H^+ and OH^- residing in a unit at the same time when the unit is filling. This is acceptable for modeling purposes.

4.7.8 Sample Points and Sample Hold Times

Some vessels in the model require sampling based on the Integrated Sampling Analysis Requirements Document (*ISARD*). If a vessel has a sample hold time, the vessel will fill to a designated level and hold for the prescribed “sample” time. When the hold time has expired, the vessel, if required, will perform its chemical operations (chem-adds, reactions, and so on) and become ready for discharge. The sample hold times include the expected time required to pull a sample from the vessel, analyze the sample, and return the results back to operators that verifying the contents of the vessel can continue to the next unit operation. The current model is based on the assumption that the samples always meet specifications and rework of the vessel contents is not required.

Sample points and their sample logic are summarized in Appendix C while sample hold times are provided in Appendix E.

4.7.9 Chemical Reactions

Certain unit operations in the model undergo chemical reactions. The chemical reactions are described later in this document and are presented in the sequence in which they occur in each unit operation. A chemical reaction is made up of reactants and products and is based on a simple stoichiometric reaction balance. A reaction conversion is given for the reaction and is applied to the first reactant only. If the reaction cannot reach the desired conversion, then the reaction will continue until all of the limiting reactant has been used up. The reaction subtracts the reactants used from the component array and adds the products generated to the component array. If the reactions involve phase changes, reactants and products are moved to the corresponding liquid/solid/gas/oxide positions in the arrays. Volume is recalculated after the reactions.

4.7.10 Splits

Splits are used in the model to demonstrate the entrainment of components in certain processes and the separation of components in other processes. Split values are determined based on the decontamination factors (DFs) of the unit operation, e.g., split to overhead = $1 / DF$. Splits are performed in the evaporators, condensers, melters, and offgas systems using either percents or fractions. The splits are component based and are applied to the component array of the unit operation. The fraction or percent of that particular component is subtracted from the component array of the unit operation performing the splits and added to the component array designated by the split table. The remaining material in the unit operation performing the split exits out of the other exit stream.

If the unit operation is an accumulation-scrubber (see Table 2 for equipment classes), the material that is removed using the split is not transferred to another unit operation. Rather, it is added to an accumulating array where captured material is stored. Components cannot be subtracted from the accumulating array, only added to it.

The split constants for the unit operations applicable are summarized in Appendix D.

4.7.11 Primary and Secondary Process Waters

Many processes such as line flush, sodium dilution, solid wash, and oxidative wash require the use of process waters. Process condensate from the Pretreatment Process Condensate Vessel (RLD-TK-00006A) is the preferred source (primary source) if sufficient volume is available at the time when it is needed. Process water is the secondary choice and is only used if the primary source is unavailable or insufficient. The contents of process condensate change constantly as RLD-TK-00006A receives condensates from the Waste Feed Evaporator Condensate Vessel and the Treated LAW Evaporator Condensate Vessel where the feeds to the evaporators vary.

4.7.12 Inhibited Water

Inhibited water is used for line flushes before and after wastes are transferred to the WTP from the Tank Farm. Inhibited water is also used for line flush into a UFP2 vessel after a UFP1 vessel empties its contents entirely (i.e., reach the heel), for power flushing, and for flushing the lines from UFP2 to HLP-VSL-00027A/B after solid discharge. Inhibited water is a mixed solution of 0.01M NaOH and 0.011M NaNO_2 (i.e., $[\text{Na}^+] = 0.021\text{M}$, $[\text{OH}^-] = 0.01\text{M}$, and $[\text{NO}_2^-] = 0.011\text{M}$).

4.7.13 Line Flushes

Line flushes are applied to the Dynamic (G2) Flowsheet to mitigate: 1) precipitation of salts per the *Interface Control Document (ICD) for Waste Feed* (24590-WTP-ICD-MG-01-019), 2) hydrogen generation per the *Hydrogen in Piping and Ancillary Vessels (HPAV) - Plant Availability Assessment* (24590-WTP-RPT-M-06-002), and 3) plugging of process lines per the *Hanford Waste Treatment and Immobilization Plant (WTP) Project Response Plan for Resolution of Issues Identified by the Comprehensive Review of the WTP Flowsheet and Throughput* (24590-WTP-PL-ENG-06-0008).

The ICD flushes are conducted using inhibited water and include the lines from the Tank Farm to the HLP-VSL-00022 and FRP-VSL-00002A/B/C/D vessels as discussed in the following.

Tank Farm to HLP-VSL-00022

Prior to an HLW batch transfer, HLP-VSL-00022 receives 2,500 gallons of inhibited water. HLP-VSL-00022 receives an additional 2,000 gallons of inhibited water after the Tank Farm batch transfer is completed and before the vessel is sampled.

At the end of the post-transfer flush, PWD-VSL-00043 and PWD-VSL-00033 will simultaneously receive 2,900 gallons and 100 gallons of inhibited water, respectively. Due to the dynamic nature of the flowsheet, PWD-VSL-00043 and PWD-VSL-00033 vessels could be in different operating modes when flushing takes place. The flush water can only be pumped into the Plant Wash and Disposal System (PWD) vessels when they are in the “empty” or “fill” modes, or otherwise be delayed.

Tank Farm to FRP-VSL-00002A/B/C/D

A LAW batch may fill one, two, or three Waste Feed Receipt Vessels depending on the size of the batch. The 2,500 gallons of pre-transfer inhibited water will be sent to the first receiving vessel prior to the batch delivery while the 2,000 gallons of post-transfer inhibited water will be sent to the last receiving vessel prior to sampling.

At the end of the post-transfer flush, PWD-VSL-00043 and PWD-VSL-00033 will simultaneously receive 2,900 gallons and 100 gallons of inhibited water, respectively. The operating logic for PWD-VSL-00043 and PWD-VSL-00033 is the same as those discussed above.

The HPAV and line plugging flushes are conducted using process condensate (primary source) or process water (secondly source) for Pretreatment vessels, however only process water can be used for flushes to the LAW and HLW equipment. These line flush operations can be triggered by: 1) waste transfer, 2) sampling, and 3) time. Transfer flushes are conducted after a waste batch transfer from the upstream tank to the downstream tank; sampling flushes are made after a sample is pulled from the vessel; and time flushes are carried out regularly at the specified time interval. In most cases, an origin of flush is associated with multiple destinations of flushes as the results of dead legs and piping configurations. The triggers for the line flush operations are summarized in Table 3, Table 4, and Table 5. The full list of line flushes including the triggers and the associated dead lag and piping configuration flushes is presented in Table H-1.

Table 3 Transfer Flushes

Stream Number (STRN)	Upstream Name	Downstream Name
FEP-04	FEP-VSL-00017A	FEP-SEP-00001A
FEP-07	FEP-VSL-00017A	FEP-SEP-00001B
FEP-12	FEP-VSL-00017B	FEP-SEP-00001A
FEP-15	FEP-VSL-00017B	FEP-SEP-00001B
FRP-01	FRP-VSL-00002A	FEP-VSL-00017A
FRP-02	FRP-VSL-00002A	FEP-VSL-00017B
FRP-03	FRP-VSL-00002A	UFP-VSL-00001A
FRP-04	FRP-VSL-00002A	UFP-VSL-00001B
FRP-05	FRP-VSL-00002B	FEP-VSL-00017A
FRP-06	FRP-VSL-00002B	FEP-VSL-00017B
FRP-07	FRP-VSL-00002B	UFP-VSL-00001A
FRP-08	FRP-VSL-00002B	UFP-VSL-00001B
FRP-09	FRP-VSL-00002C	FEP-VSL-00017A
FRP-10	FRP-VSL-00002C	FEP-VSL-00017B
FRP-11	FRP-VSL-00002C	UFP-VSL-00001A
FRP-12	FRP-VSL-00002C	UFP-VSL-00001B
FRP-13	FRP-VSL-00002D	FEP-VSL-00017A
FRP-14	FRP-VSL-00002D	FEP-VSL-00017B
FRP-15	FRP-VSL-00002D	UFP-VSL-00001A
FRP-16	FRP-VSL-00002D	UFP-VSL-00001B
FRP-41	Tank-Farm-HLW	HLP-VSL-00022
FRP-44	Tank-Farm-LAW	FRP-VSL-00002A
FRP-45	Tank-Farm-LAW	FRP-VSL-00002B
FRP-46	Tank-Farm-LAW	FRP-VSL-00002C
FRP-47	Tank-Farm-LAW	FRP-VSL-00002D
HLP-03	HLP-VSL-00022	UFP-VSL-00001A

Stream Number (STRN)	Upstream Name	Downstream Name
HLP-04	HLP-VSL-00022	UFP-VSL-00001B
HLP-05	HLP-VSL-00022	FEP-VSL-00017A
HLP-06	HLP-VSL-00022	FEP-VSL-00017B
HLP-13	HLP-VSL-00028	HFP-VSL-00005
HLP-15	HLP-VSL-00028	HFP-VSL-00001
HLP-22	HLP-VSL-00027A	HLP-VSL-00028
HLP-26	HLP-VSL-00027B	HLP-VSL-00028
HLW-04	HFP-VSL-00001	HFP-VSL-00002
HLW-17	HFP-VSL-00005	HFP-VSL-00006
HLW-29	HOP-SCB-00001	RLD-VSL-00007
HLW-35	HOP-VSL-00903	RLD-VSL-00007
HLW-39	HOP-SCB-00002	RLD-VSL-00007
HLW-44	HOP-VSL-00904	RLD-VSL-00007
HLW-51	RLD-VSL-00007	PWD-VSL-00043
HLW-81	HDH-VSL-00003	RLD-VSL-00007
HLW-85	HDH-VSL-00001	HDH-VSL-00003
LCP-1	LCP-VSL-00001	LCP-VSL-00001
LCP-2	LCP-VSL-00002	LCP-VSL-00002
LFP-1	LCP-VSL-00001	LFP-VSL-00001
LFP-10	LFP-VSL-00004	LMP-MLTR-00002
LFP-2	LCP-VSL-00001	LFP-VSL-00003
LFP-3	LCP-VSL-00002	LFP-VSL-00001
LFP-4	LCP-VSL-00002	LFP-VSL-00003
LFP-5	LFP-VSL-00001	LFP-VSL-00001
LFP-6	LFP-VSL-00003	LFP-VSL-00003
LFP-7	LFP-VSL-00001	LFP-VSL-00002
LFP-8	LFP-VSL-00003	LFP-VSL-00004
LFP-9	LFP-VSL-00002	LMP-MLTR-00001
TCP-03	TCP-VSL-00001	LCP-VSL-00001
TCP-04	TCP-VSL-00001	LCP-VSL-00002
UFP-13	UFP-VSL-00002A	PWD-VSL-00043
UFP-15	UFP-VSL-00002A	HLP-VSL-00027A
UFP-16	UFP-VSL-00002A	HLP-VSL-00027B
UFP-18	UFP-VSL-00002B	PWD-VSL-00043
UFP-20	UFP-VSL-00002B	HLP-VSL-00027A
UFP-21	UFP-VSL-00002B	HLP-VSL-00027B

Table 4 Sample Flushes

STRN	Sample Tank	Downstream Name
FRP-17	FRP-VSL-00002A	FRP-VSL-00002B
FRP-19	FRP-VSL-00002B	FRP-VSL-00002B
FRP-21	FRP-VSL-00002C	FRP-VSL-00002C
FRP-23	FRP-VSL-00002D	FRP-VSL-00002C
HLP-02	HLP-VSL-00022	HLP-VSL-00022
FEP-02	FEP-VSL-00017A	FEP-VSL-00017A
FEP-10	FEP-VSL-00017B	FEP-VSL-00017B
CXP-43	CXP-VSL-00026A	CXP-VSL-00026A
CXP-44	CXP-VSL-00026B	CXP-VSL-00026B
CXP-45	CXP-VSL-00026C	CXP-VSL-00026C
RDP-21	RDP-VSL-00002B	RDP-VSL-00002B
TLP-07	TLP-VSL-00009A	TLP-VSL-00009A
TLP-08	TLP-VSL-00009B	TLP-VSL-00009B
HLP-20	HLP-VSL-00027A	HLP-VSL-00027A
HLP-24	HLP-VSL-00027B	HLP-VSL-00027B
HLP-11	HLP-VSL-00028	HLP-VSL-00028
HLW-06	HFP-VSL-00001	HFP-VSL-00001
HLW-19	HFP-VSL-00005	HFP-VSL-00005
HLW-55	RLD-VSL-00007	RLD-VSL-00007

Table 5 Time Flushes

STRN	Upstream Name	Downstream Name	Time between Flushes (hrs)
FEP-17	FEP-SEP-00001A	UFP-VSL-00001A	450
FEP-18	FEP-SEP-00001A	UFP-VSL-00001B	450
FEP-20	FEP-SEP-00001B	UFP-VSL-00001A	450
FEP-21	FEP-SEP-00001B	UFP-VSL-00001B	450
UFP-02	UFP-VSL-00001A	UFP-VSL-00001A	1,965
UFP-08	UFP-VSL-00001B	UFP-VSL-00001B	1,965
UFP-05	UFP-VSL-00001A	UFP-VSL-00002B	524
UFP-06	UFP-VSL-00001A	UFP-VSL-00002A	524
UFP-11	UFP-VSL-00001B	UFP-VSL-00002B	524
UFP-12	UFP-VSL-00001B	UFP-VSL-00002A	524
TLP-10	TLP-SEP-00001	TCP-VSL-00001	164
HLW-37	HOP-HEME-00001	HOP-VSL-00903	4,380
HLW-47	HOP-HEME-00002	HOP-VSL-00904	4,380
LFP-11	LFP-VSL-00002	LMP-MLTR-00001	4
LFP-12	LFP-VSL-00004	LMP-MLTR-00002	4

It is important to note that a trigger from above can result in flushes into multiple destinations due to dead legs and piping configurations. Details of the flushing destinations and associated volumes are given in Table H-1.

4.7.14 Supplemental LAW

Two pseudo tanks are included in the model as optional features. The pseudo tanks are named SUPPLEMENTAL-LAW-TREATED and SUPPLEMENTAL-LAW-RECYCLE. SUPPLEMENTAL-LAW-TREATED is created to store the excess treated LAW feed due to the Pretreatment / LAW Vitrification throughput differential. SUPPLEMENTAL-LAW-RECYCLE is created to store recycles from the LAW SBS and Wet Electrostatic Precipitator (WESP). Switches are provided to turn on/off the features depending on model run scenarios. Features can be activated separately of one another. The default states of the switches are “on” for SUPPLEMENTAL-LAW-TREATED and “off” for SUPPLEMENTAL-LAW-RECYCLE. Details of the operating logic are described below.

SUPPLEMENTAL-LAW-TREATED

- 1) TCP-VSL-00001 can receive concentrate from TLP-SEP-00001 at all times.
- 2) TCP-VSL-00001 is filled to its set volume (75,000 gallons) initially and is maintained at, or above this level except when transferring out to LCP-VSL-00001 and LCP-VSL-00002.
- 3) TCP-VSL-00001 transfers material to LCP-VSL-00001 and LCP-VSL-00002 whenever they are ready to receive the transfer. During this transfer, the vessel volume of TCP-VSL-00001 can be pumped down to the minimum volume if needed (9,621 gallons).
- 4) Any excess treated LAW feed (contents that result in volume above 75,000 gallons) will be pumped to SUPPLEMENTAL-LAW-TREATED. The trigger volume is 80,000 gallons for pumping.

SUPPLEMENTAL-LAW-RECYCLE

Recycle from RLD-VSL-00005 is pumped to TLP-VSL-00009A/B. SUPPLEMENTAL-LAW-RECYCLE is inactive in the Dynamic (G2) Flowsheet Version 7.0.

4.7.15 Vessel Parameters

Vessel parameters, including minimum (heel) volumes, set volumes, maximum (heel + batch) volumes, flowrates, and sample hold times, are listed in Appendix E.

4.7.16 Solubility

Significant quantities of oxalate, phosphate, and aluminum are brought in to the WTP for processing. These solubility limited constituents exist in the liquid and solid phases in the Tank Farms and are expected to undergo further phase changes in WTP due to various Pretreatment operations, such as feed blending, solids concentration, heating, leaching, cooling, solid wash, dilution, pH adjustment, and evaporation. Phase equilibrium is of paramount importance in determining the fate of these partial soluble constituents as whether they will be sent to the LAW Facility, Pretreatment recycle streams, or HLW Facility, which can have major impacts on WTP throughput and waste loading in IHLW.

It is desirable to send more of the solubility limited constituents to the LAW Facility but the large volume of wash forward solution required to do this may bog down the CXP system, which in turn extends the processing duration. Sending wash forward solution at low hydroxide concentration may also cause

aluminum precipitation that clogs ion exchange columns and plugs transfer lines. In contrast, allowing too much oxalate and phosphate to the Pretreatment recycle streams from wash backward will create a flywheel effect that reduces the throughput of wastes at ultrafiltration (Note: flywheel effect is the process phenomenon within the Ultrafiltration Process (UFP) -> Plant Wash and Disposal Process (PWD) -> Waste Feed Evaporation Process (FEP) -> UFP loop where oxalate and phosphate dissolve in the UFP-VSL-00002A/B vessels during wash backward, recycle to the PWD and FEP systems, re-precipitate in the FEP-SEP-00001A during evaporation, and accumulate again in the UFP-VSL-00002A/B vessels during solids concentration). Finally, sending more aluminate and gibbsite to the HLW Facility will produce more IHLW glasses.

Solubility correlations have been developed and their applications to the G2 model are discussed below. It is noted that these correlations were derived by the WTP as first order attempts to address the flowsheet concerns above. There are various uncertainties in these correlations as they were derived primarily based on literature values as Hanford tank waste specific experimental data seldom exists.

4.7.16.1 Solubility Correlations

Oxalate Solubility

Oxalate ($C_2O_4^{-2}$) phase equilibrium is calculated with the following equations:

$$NaMF = LiqNaMoles / [2 * (LiqNaMoles + LiqKMoles) + LiqH2OMoles] \quad (Eq. 5)$$

$$\ln(\lambda_{C_2O_4-2}) = (a + b(NaMF) + c(NaMF^2) + d(NaMF^3)) * T_K \quad (Eq. 6)$$

$$\ln(\lambda_{Na+}) = (e + f(NaMF) + g(NaMF^2) + h(NaMF^3)) * T_K \quad (Eq. 7)$$

$$\ln(C_{C_2O_4-2}) = \ln(Q) - \ln(\lambda_{C_2O_4-2}) - 2 * \ln(C_{Na+}) - 2 \ln(\lambda_{Na+}) - \ln(T_K) \quad (Eq. 8)$$

Where:

NaMF	= Sodium mole fraction (unitless),
$\lambda_{C_2O_4-2}$	= Activity coefficient of the oxalate ion (unitless),
λ_{Na+}	= Activity coefficient of the sodium ion (unitless),
$C_{C_2O_4-2}$	= Oxalate concentrate at equilibrium (gmol/kg H2O),
C_{Na+}	= Sodium concentration at equilibrium (gmol/kg H2O),
T_K	= Vessel temperature (K),

The constants for Equations 5 through 8 are given as:

Constant	Value
a	-0.0220206
b	-0.1028143
c	-1.016929
d	17.1877483
e	-0.0008179
f	-0.0134259
g	0.92062137

h	-9.7239226
ln(Q)	-4.21128

If the concentration of oxalate is below the calculated solubility, solid oxalate and associated solid sodium dissolve until:

- 1) Concentration of oxalate reaches the solubility (excess solid oxalate and solid sodium) or
- 2) Solid oxalate has completely depleted (solid oxalate limited)

If the concentration of oxalate is above the calculated solubility, liquid oxalate and associated liquid sodium precipitate until:

- 3) Concentration of oxalate reaches solubility or
- 4) Liquid oxalate has completely depleted (liquid oxalate limited)

The oxalate dissolution/precipitation reactions are given as:

Oxalate concentration will not reach solubility when conditions 2 or 4 are encountered. Details related to the development of the oxalate solubility equations are given in CCN 160518.

Phosphate Solubility

Phosphate is partitioned into “soft” and “hard” components, designated in the model as “PO4-3” and “PO4-3(HARD)”, respectively. Partitioning is done in accordance with the phosphate leach factors given in the TFC feed vector, e.g., the unleachable phosphate is converted to “PO4-3(HARD)”. The “soft” or soluble PO4-3 is treated as trisodium phosphate (Na_3PO_4) and the solubility is a function of supernatant sodium, hydroxide, and fluoride concentrations, and temperature (24590-WTP-M4C-V37T-00009)

$$C_{\text{PO}_4} = \exp(A/T_K + B) * C_{\text{Na}}^C * C_{\text{OH}}^D * C_{\text{F}}^E \quad (\text{Eq. 9})$$

Where:

C_{PO_4} = Phosphate concentration at equilibrium (gmol/kg H_2O),
 C_{Na} = Sodium concentration (gmol/kg H_2O),
 C_{OH} = Hydroxide concentration (gmol/kg H_2O),
 C_{F} = Fluoride concentration (gmol/kg H_2O),
 T_K = Temperature (K).

Lower bounds are set for $C_{\text{OH}} = 0.01$ gmol/kg H_2O and $C_{\text{F}} = 0.007$ gmol/kg H_2O . The constants for Equation 9 are given as:

Constant	Value
A	-5298.7
B	15.1368
C	-1.0050
D	-0.1280
E	-0.4030

The phosphate dissolution/precipitation reactions are given as:

If the concentration of $\text{PO}_4^{-3} (\text{l})$ is below the calculated solubility, $\text{PO}_4^{-3} (\text{s})$ and associated $\text{Na}^+ (\text{s})$ dissolve until:

- 1) Concentration of $\text{PO}_4^{-3} (\text{l})$ reaches the solubility [excess $\text{PO}_4^{-3} (\text{s})$ and $\text{Na}^+ (\text{s})$] or
- 2) $\text{PO}_4^{-3} (\text{s})$ has completely depleted [$\text{PO}_4^{-3} (\text{s})$ limiting]

If the concentration of $\text{PO}_4^{-3} (\text{l})$ is above the calculated solubility, $\text{PO}_4^{-3} (\text{l})$ and associated $\text{Na}^+ (\text{l})$ precipitate until:

- 3) Concentration of $\text{PO}_4^{-3} (\text{l})$ reaches solubility or
- 4) $\text{PO}_4^{-3} (\text{l})$ has completely depleted [$\text{PO}_4^{-3} (\text{l})$ limiting]

$\text{PO}_4^{-3} (\text{l})$ concentration will not reach solubility when conditions 2 or 4 are encountered. Details related to the development of the phosphate solubility equation are given in 24590-WTP-M4C-V37T-00009.

Aluminum Solubility

The TFC feed vector provides the quantities of aluminum in “ $\text{Al}(\text{OH})_4^-$ ” and “ Al^{+3} ” forms in the liquid and solid phases. To support aluminum solubility modeling, the PE flowsheet engineers perform feed vector charge balance calculations in accordance with methods discussed in Appendix I. The G2 model tracks aluminum in the liquid phase as “ $\text{Al}(\text{OH})_4^-$ ”, in the solid phase as “ $\text{Al}(\text{OH})_3$ ” and “ Al^{+3} ”. Only the easy to dissolve gibbsite and soluble phase aluminate will participate in the phase equilibrium calculations. The phase equilibrium is calculated using equations from CCN 160514 or CCN 221451, depending on the vessel temperatures. It shall be noted that the solubility corrections are provided in reversible forms at each temperature. The $\text{OH} = \text{Function} (\text{Al})$ correlation is used in unit operations where caustic addition is required, e.g., to determine the caustic volume for gibbsite dissolution. The $\text{Al} = \text{Function} (\text{OH})$ correlation is applied to unit operations where aluminum phase equilibrium is calculated, e.g., to dissolve gibbsite or to precipitate aluminate.

CCN 160514 (Temperature = 25 °C)

$$S_{\text{OH}} = e * C_{\text{Al}} + f * C_{\text{Al}}^2 + g * C_{\text{Al}}^3 \quad (\text{Eq. 10})$$

$$S_{\text{Al}} = \sqrt[3]{\left(j + \frac{C_{\text{OH}}}{2g}\right) + \sqrt{\left(j + \frac{C_{\text{OH}}}{2g}\right)^2 + k}} + \sqrt[3]{\left(j + \frac{C_{\text{OH}}}{2g}\right) - \sqrt{\left(j + \frac{C_{\text{OH}}}{2g}\right)^2 + k}} + l$$

or

$$= 3.0 \text{ gmol Al}(\text{OH})_4^-/\text{kg H}_2\text{O at maximum solubility} \quad (\text{Eq. 11})$$

Where:

C_{OH} = Hydroxide concentration (gmol/kg H_2O)
 C_{Al} = Aluminate concentration (gmol/kg H_2O)

S_{Al} = Aluminate solubility (gmol/kg H₂O)
 S_{OH} = Hydroxide concentration when aluminate is at solubility (gmol/kg H₂O)

The constants for Eq. 10 and Eq. 11 are given as:

Constant	Value
e	12.298114
f	-7.502178277
g	1.50964729
j	-2.20180336
k	-2.3228E-05
l	1.656496924

CCN 221451 (25 °C < Temperature ≤ 45 °C)

$$S_{Al} = e * C_{OH} + f * C_{OH}^2 + g * C_{OH}^3 \quad (\text{Eq. 12})$$

$$S_{OH} = \sqrt[3]{\left(j + \frac{C_{Al}}{2g}\right) + \sqrt{\left(j + \frac{C_{Al}}{2g}\right)^2 + k}} + \sqrt[3]{\left(j + \frac{C_{Al}}{2g}\right) - \sqrt{\left(j + \frac{C_{Al}}{2g}\right)^2 + k}} + l \quad (\text{Eq. 13})$$

Where:

$$e = (7.07864e - 6) * T^4 - (9.206808e - 4) * T^3 + (4.47814e - 2) * T^2 - (9.586194e - 1) * T + 7.680834$$

$$f = (-4.823189e - 6) * T^4 + (6.268796e - 4) * T^3 - (3.044321e - 2) * T^2 + (6.521685e - 1) * T - 5.197387$$

$$g = (7.259612e - 7) * T^4 - (9.410837e - 5) * T^3 + (4.5653e - 3) * T^2 - (9.764447e - 2) * T + 7.787686e - 1$$

$$j = \frac{-f^3}{27g^3} + \frac{fe}{6g^2}$$

$$k = \left(\frac{e}{3g} - \frac{f^2}{9g^2}\right)^3$$

$$l = -\frac{f}{3g}$$

C_{OH} = Hydroxide concentration (gmol/kg H₂O)

C_{Al} = Aluminate concentration (gmol/kg H₂O)

S_{Al} = Aluminate solubility (gmol/kg H₂O)

S_{OH} = Hydroxide concentration when aluminate is at solubility (gmol/kg H₂O)

T = Vessel temperature (°C)

Aluminum will precipitate/dissolve in accordance with the following reversible reactions

Details related to the development of the aluminum solubility correlations can be found in CCN 160514 and CCN 221451.

4.7.16.2 Assumptions

Assumptions related to solubility calculations and phase equilibrium are summarized as follows:

- 1) Oxalate exists in the forms of liquid and solid $C_2O_4^{-2}$ and phase equilibrium is reached between the two. Phase change reactions in the model ensure that one gram mole of solid $C_2O_4^{-2}$ is associated with two gram moles of solid Na^+ .
- 2) Phosphate is partitioned into “soft” PO_4^{-3} and “hard” $PO_4^{-3}(HARD)$. PO_4^{-3} exists in both liquid and solid phases but $PO_4^{-3}(HARD)$ only exists in the solid phase. Phase equilibrium is reached between liquid PO_4^{-3} and solid PO_4^{-3} . The model ensures that one gram mole of solid PO_4^{-3} is associated with three gram moles of solid Na^+ .
- 3) Aluminum exists in the liquid phase as $Al(OH)_4^-$, and in the solid phase as $Al(OH)_3$ and Al^{+3} . Phase equilibrium is reached between $Al(OH)_4^-$ and $Al(OH)_3$.
- 4) Solid $C_2O_4^{-2}$, PO_4^{-3} , and $Al(OH)_3$ can dissolve in unsaturated solutions at ambient temperature without first being leached.
- 5) Phase equilibrium is reached instantaneously in unit operations where solubility is applied, e.g., kinetics are not considered.

4.7.16.3 Applications

Solubility is calculated in the model at selected locations where phase equilibrium will impact process operation decisions. The goal is to obtain sufficient resolution in phase equilibrium chemistry while still maintaining a reasonable computation time. Ideally, solubility would be applied continuously to all WTP equipment, but that would prolong the model run time to unacceptable levels.

Generally solubility is calculated in correspondence to batch operations, for example, phase equilibrium is applied after a vessel is filled and before its contents can be discharged. However there are exceptions in some vessels where phase equilibrium is applied multiple times in a batch due to various process operations. There are also exceptions in the evaporators where phase equilibrium is applied continuously as the control for wt% solids in evaporator concentrates is important. It shall be noted that solubility is not applied to the Vittrification Facility equipment since these operations are not dependent on the phases of the soluble constituents.

Table 6 provides a summary of the equipment where solubility is applied, the temperatures when solubility is applied, and the logic for the solubility application.

Table 6 Solubility Applications

Equipment	T (°C)	Logic
FRP-VSL-00002A/B/C/D	25	After filled and before sampling
HLP-VSL-00022	25	After filled and before sampling
FEP-VSL-00017A/B	25	After filled and before discharge
FEP-SEP-00001A	42	Continuous during boil-off
UFP-VSL-00001A/B	45	After pre-heating steam condensate addition and before discharge
UFP-VSL-00002A/B	45	1) At the peak of saw-tooth operation during solids concentration, e.g., when a UFP-VSL-00002 vessel is filled to the upper set volume 2) At the end of solids concentration 3) After caustic leach 4) At the peak of saw-tooth operation during solid wash 5) At the peak of saw-tooth operation during oxidative wash
Super Tank	45	Continuous when pumping (actual operating temperature = 50 °C)
CXP-VSL-00026A/B/C	45	After filled and before sampling
TLP-SEP-00001	50	Continuous during boil-off
TCP-VSL-00001	31	Continuous when pumping
PWD-VSL-00015/16	25	After filled and pH adjustment
PWD-VSL-00044	25	After filled and pH adjustment
HLP-VSL-00027A/B	25	After filled and before discharge
HLP-VSL-00028	25	After filled and before sampling

4.7.17 Antifoaming Agent (AFA)

Antifoaming agent is added to the FEP and Treated LAW Evaporation Process (TLP) evaporators to minimize foaming during evaporator campaigns. To prevent foaming due to spargers, AFA is also added to non-Newtonian vessels in the UFP and HLW Lag Storage and Feed Blending Process (HLP) systems. AFA is composed of 50 wt% of Polypropylene Glycol (PPG) and 50 wt% of Polydimethylsiloxane (PDMS), however, AFA is always added as a mixture of 20 wt % AFA and 80 wt % water. Table 7 shows the makeup compositions of AFA used in the G2 model.

Table 7 AFA Makeup Compositions

Liquid Component	Molecular Weight (g/gmol)	Mole Fraction (gmol/gmol)	Liquid Molarity (gmol/liter)
H2O	18.015	0.999292769	54.119
PPG	3,503	6.42937e-4	0.034
PDMS	35,015	6.42937e-5	0.003

Assumptions and simplifications made for AFA modeling are as follows:

- 1) Heating and irradiation will cause the AFA to decompose (become ineffective in foam control). Decomposition products of PPG and PDMS are tracked in the model by Decomposed Polypropylene Glycol (DPPG) and Decomposed Polydimethylsiloxane (DPDMS), respectively.
- 2) Only DPPG and DPMS are present in recycle streams as residence times in the recycle loops have caused the AFA to decompose completely.
- 3) AFA aging are not considered, for example, residence time will not impact antifoam properties and decay rate is constant. In other words, fresh AFA and aged AFA have the same properties.

- 4) PPG and DPPG exhibit high water solubilities and are assumed to exist in the dissolved phase.
- 5) PDMS and DPDMS are hydrophobic and therefore exist in the suspended phase, for example, as non-aqueous phase liquids (NAPLs). As these NAPLs tend to bind with solids in the wastes, it is assumed that PDMS and DPDMS follow solids in the plant and will contribute to wt % solids calculations.
- 6) AFA and decomposed products are uniformly distributed in WTP equipment as mixing is assumed to be ideal.
- 7) The small quantities of silica in AFA and their decomposed products will not impact glass formulation.

AFA can be added simultaneously to any evaporator that is operating, however, it can only be added to a non-Newtonian vessel at a time. Target concentrations are 500 ppm (250 ppm PPG and 250 ppm PDMS) for the evaporators and 350 ppm (175 ppm PPG and 175 ppm PDMS) for the non-Newtonian vessels. AFA addition is not needed if existing concentrations are equal to or greater than the target values. It shall be noted that concentrations of PPG and PDMS may be different in the same equipment due to liquid and solid partitioning of the AFA and by the mixing and separation operations. AFA is added in accordance with the operating logic in Table 8.

Table 8 AFA Addition Operating Logic

Receiving Equipment	Addition Logic
FEP-SEP-00001A/B	<ul style="list-style-type: none"> • In the beginning of a new batch, and • Every 1-hour after.
UFP-VSL-00001A/B	<ul style="list-style-type: none"> • At the end of feed blending, and • Every 6-hours during pre-heating and discharging.
UFP-VSL-00002A/B	<ul style="list-style-type: none"> • In the beginning of a concentration cycle, • Every 6-hours during solid concentration, heating, leaching, cooling, and washing, • AFA will not be added during oxidative leach, • In the beginning of oxidative wash, • Every 6-hours during oxidative wash and solid discharge.
HLP-VSL-00027A/B	<ul style="list-style-type: none"> • Every 6-hours after initially filled to above the heel volume.
HLP-VSL-00028	<ul style="list-style-type: none"> • Every 6-hours after initially filled to above the heel volume.
TLP-SEP-00001	<ul style="list-style-type: none"> • In the beginning of a new batch, and • Every 1-hour after.

AFA decomposition occur in the evaporators and vessels once every hour. Decomposition reactions are given as:

PPG (l) → DPPG (l) CF = 0.009255 wt % / hour

PDMS (l) → PDMS (s) CF = 100 wt % (after every AFA addition)

PDMS (s) → DPDMS (s) CF = 0.009255 wt % /hour

$$CF = 1 - \left(\frac{\text{end mass}}{\text{current mass}} \right)^{1/n} \quad (\text{Eq. 14})$$

Where:

end mass = 80 wt %,
current mass = 100 wt %,
n = 24 hours

All the PPG and PDMS will be decomposed during oxidative leaching in the presence of sodium permanganate. Also, all the PPG and PDMS will be converted to DPPG and DPDMS, respectively, in FEP-VSL-00005A/B, TLP-VSL-00002, and PWD-VSL-00015, PWD-VSL-00016, and PWD-VSL-00044 to simulate the decomposition due to long residence times. This is a conservative assumption that ensures only decomposed products exist in the Pretreatment recycles. Split fractions for the AFA and decomposed products to FEP/TLP evaporator overheads are set to 1.00e-8. Split fractions of the AFA and decomposed products to LAW and HLW melter overheads are set to 0.0, for example, 100% will be combusted according to the reactions below:

4.7.18 Hydrogen Generation

Hydrogen generation rates (HGRs) can be calculated for the vessels and evaporator shown in Table 9. To reduce the amount of computations, only the worst case conditions are used for the calculations, for example, HGRs are determined for the vessels when they are filled to the upper operating volumes, for UFP-VSL-00002A/B at the end of solid concentration, and for CNP-EVAP-00001 at its highest concentration just before it can be discharged. Maximum operating temperatures are also applied. A switch is provided in the model that turns the HGR calculation feature on and off.

Table 9 Maximum Temperatures for HGR Calculations

Equipment Name	Maximum Operating Temperature (°F)
FRP-VSL-00002A/B/C/D	120
HLP-VSL-00022	150
FEP-VSL-00017A/B	122
UFP-VSL-00001A/B	194
UFP-VSL-00002A/B	194
CNP-EVAP-00001	140
CNP-VSL-00003	190
RDP-VSL-00002A/B/C	123
PWD-VSL-00033/43	141
LFP-VSL-00001/2/3/4	140
HLP-VSL-00027A/B	138

Equipment Name	Maximum Operating Temperature (°F)
HLP-VSL-00028	141
HFP-VSL-0001/5/2/6	140
HOP-SCB-00001/2	140
RLD-VSL-00005	166

Steps for the HGR calculations are described as follows.

$$\text{TOC} = 100 \times \sum (C_i \times \text{LOM}_i / \text{MW}_i) / \text{LTM} \quad (\text{Eq. 15})$$

Where:

TOC = Liquid weight percent Total Organic Carbon (dimensionless)
 C_i = Constant of a hydrogen contributing organic (kg/kg-mole)
 LOM_i = Liquid mass of a hydrogen contributing organic (kg)
 MW_i = Molecular weight of a hydrogen contributing organic (kg/kg-mole)
 LTM = Liquid total mass (kg)

The constants and molecular weights of the hydrogen contributing organics are presented in Table 10. Isodecyl Alcohol is excluded from Eq. 15 as this compound is not tracked in the G2 model and its quantity is not provided by the Tank Farms. Sugar will only be considered in the Melter Feed Preparation Vessels (MFPV) and Melter Feed Vessels (MFV).

Table 10 Hydrogen Contributing Organics and Constants

Name of Organics	Formula of Organics	C_i	MW_i	Applicable Equipment
Oxalate	C2O4-2	24	88.02	All
Formate	CHO2-	12	45.018	All
Acetate	C2H3O2-	24	59.044	All
Glycolate	C2H3O3-	24	75.044	All
Citrate	C6H5O7-3	72	189.101	All
HEDTA	C10H15N2O7-3	120	275.238	All
EDTA	C10H12N2O8-4	120	288.213	All
Sugar	C12H22O11	144	342.299	MFPVs and MFVs only
Polypropylene Glycol	PPG	2,160	3,503	All
Decomposed Polypropylene Glycol	DPPG	2,160	3,503	All

$$GH2O\alpha = \frac{1.05}{(1 + 2.4 * [NO3-] + 0.63 * [NO2-])} + \frac{0.35}{(1 + 3900 * [NO3-] + 1400 * [NO2-])} \quad (\text{Eq. 16})$$

$$GH2O\beta\gamma = \frac{0.34}{(1 + 2.4 * [NO3-] + 0.62 * [NO2-])} + \frac{0.11}{(1 + 120 * [NO3-] + 43 * [NO2-])} \quad (\text{Eq. 17})$$

Where:

[NO3-] = Nitrate molarity (gmol/L)

[NO2-] = Nitrite molarity (gmol/L)

$$GTOC\alpha = 0.5 * a_0 * f * TOC * \exp\left[\frac{-Q_{rad}}{R * T}\right] \quad (\text{Eq. 18})$$

$$GTOC\beta\gamma = a_0 * f * TOC * \exp\left[\frac{-Q_{rad}}{R * T}\right] \quad (\text{Eq. 19})$$

Where:

a_0 = 2.49×10^6 (dimensionless)

f = 0.7 (dimensionless)

Q_{rad} = 44,300 (J/mole)

R = 8.314 (J/mole-K)

T = Maximum operating temperature (K)

Specific activities and decay heat generation rates for the alpha emitting radionuclides are shown in Table 11 and the values for the beta and gamma emitting radionuclides are given in Table 12. These property values are used in Eq. 20 and Eq. 21 for decay heat calculations.

Table 11 Specific Activities and Decay Heat Rate of Alpha Emitting Radionuclides

Alpha Emitting Radionuclides	Specific Activity (Ci/g)	Decay Heat Rate (W/Ci)
233-U	0.00968	0.0286
238-Pu	17.1	0.0326
239-Pu	0.0622	0.0302
240-Pu	0.228	0.0306
241-Am	3.43	0.0328
244-Cm	80.9	0.0344

Table 12 Specific Activities and Decay Heat Rates of Beta/Gamma Emitting Radionuclides

Beta/Gamma Emitting Radionuclides	Specific Activity (Ci/g)	Decay Heat Rate (W/Ci)
60-Co	1,130	0.0154
90-Sr	136	--
90-Sr/90-Y	--	0.0067
99-Tc	0.0169	0.000501
137-Cs	86.7	--
137-Cs/137m-Ba	--	0.00495
154-Eu	270	0.00908
235-U	2.16e-6	0.0271

Decay heat rates for 90-Sr/90-Y and 137-Cs/137m-Ba include those decay products of 90-Y and 137m-Ba.

$$decayHeat\alpha = \sum (LSG_i * A_i * H_i) \quad (\text{Eq. 20})$$

$$decayHeat\beta\gamma = \sum (LSG_j * A_j * H_j) \quad (\text{Eq. 21})$$

Where:

$decayHeat\alpha$ = Decay heat rate from alpha radiation (W/kg of waste)
 LSG_i = Grams of a liquid and solid alpha emitting radionuclide in a kilogram of waste (g)
 A_i = Specific activity of an alpha emitting radionuclide (Ci/g)
 H_i = Decay heat rate of an alpha emitting radionuclide (W/Ci)
 $decayHeat\beta\gamma$ = Decay heat rate from beta/gamma radiations (W/kg of waste)
 LSG_j = Grams of a liquid/solid beta/gamma emitting radionuclide in a kilogram of waste (g)
 A_j = Specific activity of an a beta/gamma emitting radionuclide (Ci/g)
 H_j = Decay heat rate of a beta/gamma emitting radionuclide (W/Ci)

$$HGR_{rad} = f_1 * F * (decayHeat\alpha * (GH2O\alpha + GTOC\alpha) + decayHeat\beta\gamma * (GH2O\beta\gamma + GTOC\beta\gamma)) \quad (\text{Eq. 22})$$

Where:

HGR_{rad} = HGR by radiolysis (moles of H₂/day/kg waste), note: waste includes liquid and solid
 f_1 = Liquid waste weight fraction (dimensionless)
 F = 0.00895 (dimensionless).

The weight percent aluminate is calculated as follows:

$$wpctAl = \frac{100 * \left(\frac{27 * LMaloh4}{MWaloh4} \right)}{LTM} \quad (\text{Eq. 23})$$

Where:

wpctAl = Weight percent of aluminate (dimensionless)
LMaloh4 = Liquid mass of aluminate (kg)
MWaloh4 = Molecular weight of aluminate (kg/kg-mole)

$$HGR_{therm} = aT * f * TOC * (wpctAl)^{0.4} * f_1 * \exp\left(\frac{-Q_{therm}}{R * T}\right) \quad (\text{Eq. 24})$$

Where:

HGR_{therm} = HGR by thermolysis (moles H₂/day/kg waste)
aT = 2.76 x 10⁹ (dimensionless)
Q_{therm} = 89,300 (J/mole)

$$HGR = HGR_{rad} + HGR_{therm} \quad (\text{Eq. 25})$$

Where:

HGR = Total hydrogen generation rate (moles H₂/day/kg waste)

Hydrogen generation rates are converted to liters of H₂ per hour per tank at maximum temperature at 1 atm when data are recorded.

4.7.19 End of Mission Waste Handling

The common operating rules described in Section 4.7.2 are applied to the startup and operation phases of the mission. The pumping logic triggers a transfer when volume of an upstream vessel reaches above the vessel's upper set point. However, pumping will not start if the upper set volume is not reached at the end of mission when continuous feeds from the Tank Farms become unavailable. This results in some residual volumes of wastes (defined as the remaining waste above the heel and below the upper set point) in various vessels that could not be processed by the melters. The end of mission waste handling logic is implemented to force out these residual wastes sequentially downstream so that they can be processed. This ensures that canister counts from different scenario runs can be compared on equal basis.

The G2 implementation for the end of mission waste handling logic is described below:

- 1) The end of mission waste handling logic starts after the last batches of LAW and HLW feeds have left the Waste Feed Receipt Process (FRP) system and HLP-VSL-00022, respectively.
- 2) WTP line flushes are terminated (because they place waters in already empty vessels).
- 3) The 24-hour discharge cycle at PVP-SCB-00002 is stopped (because it generates large volume of recycle).
- 4) The water flow to PVP-HEME-00001 is discontinued (because it generates large volume of recycle).
- 5) Wait until the FEP evaporators have processed the original recycles in FEP-VSL-00017A/B, for example, these vessels are emptied and can be used for new recycles. Note: original recycles are generated during normal operations and new recycles are generated from residual waste processing.
- 6) Residual wastes are forced out of the HLP-VSL-00022 and FRP vessels until heel volumes are reached.

- 7) Residual wastes are forced out of UFP-VSL-00001A/B to UFP-VSL-00002A/B where the wastes are treated according to normal process procedures, such as solids concentration, wash, oxidative leach and wash, solid discharge, and filter cleaning. UFP2 solid treatments will begin after all the UFP1 residual wastes have been processed and regardless if the solid concentration target (20 wt% solids) is achieved. Wash water is recycled (new recycles) to PWD.
- 8) Two sub- end of mission processes start simultaneously after the UFP2 vessels are clear of wastes, one process is to empty the vessels on the path to HLW Melter Process (HMP) and the other is to clear the vessels on the path to LAW Melter Process (LMP).
- 9) For the HLW sub-process, wait until HLP-VSL-00028 becomes ready to receive, empty residual wastes in HLP-VSL-00027A/B.
- 10) Sample and empty residual wastes in HLP-VSL-00028.
- 11) Operate HLW Melter Feed Preparation Vessels as normal regardless if set volume can be achieved for the last batch.
- 12) Empty HLW MFPVs and MFVs completely, shut down the HMP and HLW Melter Offgas Treatment Process (HOP) processes. Before HMP and HOP are shut down, new recycles from HOP and HLW Canister Decontamination Handling (HDH) are routed to PWD through RLD-VSL-00007 according to normal operation logic.
- 13) For the LAW sub-process, empty the residual wastes from vessels in the following order: Super Tank, CXP-VSL-00026A/B/C, TCP-VSL-00001, LCP-VSL-00001/2, LFP-VSL-00001/3, and LFP-VSL-00002/4. Operate the LAW MFPVs as normal regardless if set volume can be achieved for the last batch.
- 14) Shut down LMP, LAW Melter Offgas Treatment Process (LOP), and LAW Secondary Offgas/Vessel Process (LVP) processes, and before that new recycles from LOP and LVP are routed to TLP according to normal operation logic.
- 15) Shut down FEP evaporators and store new recycles in the FEP-VSL-00017A/B vessels to prevent filling the already emptied UFP vessels. The volumes of new recycles will be recorded.
- 16) Shut down the entire WTP process when both HLW Melter Feed Process (HFP) and LAW Melter Feed Process (LFP) are clear of wastes.

Volumes in the key Pretreatment, LAW Facility, and HLW Facility vessels will be recorded before and after the end of mission logic is executed. It shall be noted that the end of mission waste handling logic described above may not represent the actual operations which will be determined by the WTP operations and maintenance contractor.

4.7.20 Heel Management

Heel management operations are performed in selected Pulse Jet Mixer (PJM) vessels to address concerns of solids accumulation in stationary heels due to inadequate mixing. Two types of heel management operations can be performed including: a) heel dilution, and b) heel cleanout. Heel dilution is a normal operation that is performed in Newtonian vessels at regular time intervals, while heel cleanout is an off-normal operation that is performed in non-Newtonian vessels as needed. For modeling purpose, heel cleanout is also performed at regular time intervals in G2. Both heel dilution and heel cleanout involve three steps: a) dilution, b) fluidization, and c) removal. Removal is carried out with a portable pump that is able to discharge to lower heel levels. The portable pump has a 50 gpm capacity. General rules of the heel management operations are discussed as follows.

Heel Dilution

- 1) Continue normal operations until a scheduled date for heel dilution is reached
- 2) Discharge wastes with the vessel's fixed pump until the fixed pump heel level is reached
- 3) Configure jumpers/hoses and install a portable pump in parallel with Steps 1 and 2, preparation time is not added
- 4) Continue to discharge wastes until the portable pump heel level is reached
- 5) Fill vessel to PJM operation level with dilution fluid such as LAW feed from FRP-VSL-00002A/B/C/D, process condensate, or DI water in priority order
- 6) Fluidize vessel contents for 1 hour
- 7) Discharge fluidized contents to portable pump heel level
- 8) Flush jumpers/hoses with inhibited water
- 9) Reconfigure jumpers/hoses and uninstall the portable pump, holdup time is not added

Heel Cleanout

- 1) Continue normal operations until a scheduled date for heel cleanout is reached
- 2) Discharge wastes with the vessel's fixed pump until the fixed pump heel level is reached
- 3) Configure jumpers/hoses and install a portable pump, the preparation process takes 8 hours
- 4) Continue to discharge wastes until the portable pump heel level is reached
- 5) Fill vessel to PJM operation level with cleanout fluid, e.g., concentrated solids from upstream vessel(s) originated from UFP-VSL-00002A/B
- 6) Fluidize vessel contents for 1 hour
- 7) Discharge fluidized contents to portable pump heel level
- 8) Flush jumpers/hoses with inhibited water
- 9) Reconfigure jumpers/hoses and uninstall the portable pump, the process takes 8 hours

Table 13 provides the specifics for the heel management operations. The logic for triggering the heel management operations are discussed as appropriate in sub-sections under Section 4.8.

4.7.21 Fate of Mercury

Mercury undergoes complicate transformations in various WTP processes with reduction, oxidation, vaporization, and condensation reactions (24590-WTP-RPT-PR-01-011). For simplicity, mercury is tracked as " Hg^{+2} " in liquid and solid. A gaseous state mercury " Hg " is also used for material balance in the offgas systems. Systems that require special treatments for the fate of mercury modeling include the LMP, LOP, TLP, HMP, HOP, and PWD. Refer to these system sub-sections under Section 4.8 for details.

Table 13 Heel Management Operation Specifics

Vessel	Management Type	Frequency (times/yr)	PJM Operating Level (gal)	Pump Heel (gal)		Lineflush Volume (gal)	Receipt Vessel
				Fix	Portable		
HLP-VSL-00022	Dilution	1	18,478	29,486	1,144	210	UFP-VSL-00001B
FEP-VSL-00017A	Dilution	1	5,720	5,692	1,817	n/a	FEP-SEP-00001A
FEP-VSL-00017B	Dilution	1	5,720	5,692	1,817	n/a	FEP-SEP-00001A
UFP-VSL-00001A	Dilution	2	5,757	7,704	1,191	150	UFP-VSL-00002A
UFP-VSL-00001B	Dilution	2	5,757	7,704	1,191	150	UFP-VSL-00002B
HLP-VSL-00027A	Cleanout	2	10,642 - 20,000 ^{a)}	10,600	773	165	HLP-VSL-00028
HLP-VSL-00027B	Cleanout	2	10,642 - 20,000 ^{a)}	10,600	773	165	HLP-VSL-00028
HLP-VSL-00028	Cleanout	2	11,556 - 20,000	27,000 ^{b)}	770 ^{b)}	165	HFP-VSL-00001/5

^{a)} Desired volume range for PJM operation, however, the upper bound can be exceeded so that an entire UFP2 solid discharge batch can be received.

^{b)} The lower bound may not be reached due to a restriction of not sending partial batches to the HLW Melter Feed Prep Vessels.

4.8 System Specific Operating Logic

The following sections provide a system-by-system description of the operating logic used in the Dynamic (G2) Model. Graphical representations of the systems are found in Appendix F and can be used in conjunction with the reading for a better understanding of the model layout. All reactions provided in the descriptions occur in the order in which they are presented.

It is noted that Version 7.0 of the Dynamic (G2) Model is configured to perform: a) the baseline UFP2 leaching with gibbsite, or b) the optional UFP2 leaching with boehmite, or c) the optional UFP1 leaching with gibbsite flowsheet operations. The optional UFP2 leaching with boehmite flowsheet differs from the baseline flowsheet in how caustic leach reactions are performed, the optional UFP1 leaching flowsheet differs from the baseline flowsheet primarily in vessels where caustic leach reactions are performed, but also in feed blending, recycle handling, and solid processes. Operating logic and parameters applicable to the optional flowsheets are discussed in Appendices L and M.

4.8.1 Waste Feed Receipt Process (FRP) System

Vessel Tag #	Equipment Description
FRP-VSL-00002A	Waste Feed Receipt Vessel
FRP-VSL-00002B	Waste Feed Receipt Vessel
FRP-VSL-00002C	Waste Feed Receipt Vessel
FRP-VSL-00002D	Waste Feed Receipt Vessel

The Waste Feed Receipt Vessels receive batch transfers of LAW feed and associated pre-transfer and post-transfer line flushes of inhibited water from the Tank Farm. These vessels also receive line flush water from various operations shown in Table H-1. In general, the transfer lines are flushed after each use and the flush water goes to not only the pumping and receiving vessels, but also other FRP and FEP vessels as the result of piping configurations. Transfers from HLP-VSL-00022 to UFP-VSL-00001A/B will also lead to significant volume of flush water to the FRP-VSL-00002A vessel. Headspace, which is defined as the remaining usable volume after the vessel is filled with slurry wastes, is reserved in each vessel for the line flush water. No pumps can fill the vessels to above their maximum volumes.

LAW batches from the Tank Farm greater than 1 million gallons are commonly seen. Also, LAW feeds are generally high in sodium concentration and low in wt % solids. Several rules that control the acceptance of batches into the plant exist in this system. The rules are narrated as follows:

- 1) At least three of the four Waste Feed Receipt Vessels must be empty before a new LAW batch can be received. This ensures that FRP is able to receive 1 million gallons of LAW feed, per the WTP contract requirement.
- 2) An input parameter is defined in the model that specifies the number of vessels that must be reserved as empty after a LAW batch has been received. The default for this parameter is zero.
- 3) Batches can be delivered sequentially or non-sequentially. Sequential delivery means that the LAW and HLW batches are delivered strictly in order based on the feed sequence in the feed vector. Non-sequential delivery means that if the plant needs a batch of LAW, then a batch of LAW can be delivered ahead of a batch of HLW that has not been delivered. The same logic applies to HLW batches. There is one restriction to non-sequential delivery: HLW batches are not allowed to get X number of days ahead of the last LAW batch that is processed. This is necessary to prevent the plant from processing HLW years ahead of schedule. This restriction is ignored by default as the value for X is set to 9999 days.

- 4) Another rule/feature implemented in this system is batch delay. Each batch in the feed vector is associated with a forecasted delivery date by the Tank Farm. When batch delay is selected, a batch cannot be processed until the Tank Farm delivery date is reached. The application of this feature is set to false by default.
- 5) The first LAW batch cannot be received until the model reaches the initial LAW delivery date. The initial LAW delivery date can be changed based on the desired scenario.
- 6) The first HLW batch cannot be received until the model reaches the initial HLW delivery date. The initial HLW delivery date can be changed based on the desired scenario.

A vessel receives feed until the tank has reached its set volume or the full batch has been received from the Tank Farm. Separate batches will not mix in the same vessel except for the residual material remaining in the heel.

Oxalate, phosphate, and aluminum solubility are applied at 25 °C after the transfer is complete. Then the vessel is sampled and held for the prescribed hold time. When the hold time has expired, the vessel becomes available to be emptied to UFP. Besides normal waste processing, LAW feeds from the FRP vessels are also used for heel dilution operations as discussed in Section 4.7.20. It is assumed that vessel contents have cooled down to 25 °C after transfer from the Tank Farm, held for sampling, and waiting to be discharged. Due to the large size of LAW batches, some wastes may be stored in the FRP vessels for months before they can be processed. Vessels will be pumped in the order in which they receive waste. Once a Waste Feed Receipt Vessel has reached its minimum volume, the vessel makes itself available to receive another batch. Once three of the four Waste Feed Receipt Vessels are empty, another batch is delivered from the Tank Farm.

Figure F-3 provides a graphical illustration of the FRP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the FRP.

4.8.2 Waste Feed Evaporation Process (FEP) System

Vessel Tag #	Equipment Description
FEP-VSL-00017A	Waste Feed Evaporator Feed Vessel
FEP-VSL-00017B	Waste Feed Evaporator Feed Vessel

The Waste Feed Evaporator Feed Vessels can receive feeds from the following vessels:

Vessel Tag #	Equipment Description
FRP-VSL-00002A	Waste Feed Receipt Vessel (heel dilution)
FRP-VSL-00002B	Waste Feed Receipt Vessel (heel dilution)
FRP-VSL-00002C	Waste Feed Receipt Vessel (heel dilution)
FRP-VSL-00002D	Waste Feed Receipt Vessel (heel dilution)
PWD-VSL-00015	Acidic/Alkaline Effluent Vessel
PWD-VSL-00016	Acidic/Alkaline Effluent Vessel
PWD-VSL-00044	Plant Wash Vessel
RDP-VSL-00002B	Spent Resin Slurry Vessel

FEP-VSL-00017A and FEP-VSL-00017B operate in an alternating order and receive feeds from one of the vessels listed above in a first come, first serve fashion. A vessel receives feed until the tank has reached its set volume which may require multiple transfers from the upstream sources. Headspace is

reserved as the vessel continues to receive line flush water (see Table H-1 for details of various sources of flushing). Solubility is applied at 25 °C after the vessel is filled. The FEP-VSL-00017A/B vessels are restricted not to receive wastes with solids concentration greater than 2 wt%. Flags will be raised if the wt% solids of the upstream wastes exceed the target value. The contents of the vessels are pumped to FEP-SEP-00001A or FEP-SEP-00001B as appropriate.

Once a year, a heel dilution is performed in FEP-VSL-00017A/B to reduce solids concentration in the heel that may have accumulated. Fluids used for dilution are LAW feeds from FRP-VSL-00002A/B/C/D, process condensate, or DIW in preferred orders. The FEP-VSL-00017A/B heel dilution is scheduled to separate with other heel dilution operations in HLP-VSL-00022 and UFP-VSL-00001A/B. The portable pump connects FEP-VSL-00017A/B with FEP-SEP-00001A. Refer to Section 4.7.20 for further details on general rules of heel dilution and FEP-VSL-00017A/B specific volume parameters.

Vessel Tag #	Equipment Description
FEP-SEP-00001A	Waste Feed Evaporator
FEP-SEP-00001B	Waste Feed Evaporator

The Waste Feed Evaporator reboiler and separator vessel are modeled as one unit, for example, their volumes are combined. Evaporator volume is maintained at a constant level (set-volume) when operating. Concentrate will initially accumulate then get discharged as the volume rises above the set-volume. The evaporators receive feeds from FEP-VSL-00017A and FEP-VSL-00017B and associated line flush water. FEP-SEP-00001A is dedicated for processing recycles while FEP-SEP-00001B is used for processing the waste feeds through FEP. The FEP-SEP-00001B evaporator train is inactive in the baseline version of the model owing to the flowsheet design of waste feed bypassing FEP. Processing rates of the evaporators are limited by a boil-off rate of 30 gallons per minute (gpm), with 2 gpm used for the evaporator recycle spray resulting in a modeled boil-off rate of 28 gpm. The main purpose of the evaporator is to reduce volume by concentrating the recycle to a SpG of 1.27 and/or a weight percent solids of 8.9 %, whichever comes first. The evaporator feed pump and concentrate pump have maximum capacities at 50 gpm and 34 gpm, respectively. These pump rates are adjusted dynamically at every time step so that the boil-off rate and the SpG and/or weight percent solids target can be met.

Oxalate and phosphate that come from recycles from the UFP operations tend to precipitate in the evaporator after boil-off. Solubility is applied continuously at the flash evaporation temperature (42 °C) which may slightly alter the SpG and/or weight percent solids values of the FEP evaporator bottom product. Recycle concentrate is routed to a UFP1 vessel in accordance with the current UFP1 operating conditions as follows:

As soon as a UFP1 vessel finishes its feed blending and pre-heating operations, this vessel becomes a priority vessel for receiving evaporator bottom products, e.g., it will be used when evaporator starts the next batch operation regardless of the alternate UFP1 vessel mode.

However, if the evaporator is currently feeding the alternate UFP1 vessel, this batch operation will continue (e.g., will not stop due to a new UFP1 vessel comes on line) until either: 1) the feeding FEP17A/B vessel becomes empty, or 2) the receiving alternate UFP1 vessel is full.

Feeding can be switched from the current receiving UFP1 vessel when it gets full to the alternate UFP1 vessel if it still has storage volume available. Evaporator turns idle when both UFP1 vessels are not available.

To minimize foaming, AFA is added to the evaporator when it starts receiving a new batch from a feed tank. AFA will be replenished after that in an 1-hour interval to make up losses due to decomposition and discharge. Target concentrations for PPG and PDMS are discussed in Section 4.7.17.

The offgas from FEP-SEP-00001A is routed to FEP-DMST-00001A and the offgas from FEP-SEP-00001B is routed to FEP-DMST-00001B. Constituents are boiled off by the evaporators based on splits found in Table D-1.

Vessel Tag #	Equipment Description
FEP-DMST-00001A	Waste Feed Evaporator Demister
FEP-DMST-00001B	Waste Feed Evaporator Demister

The Waste Feed Evaporator Demisters, which for modeling purposes also perform the role of the condensers, are modeled as FEP-DMST-00001A and FEP-DMST-00001B. The demisters receive offgas from the Waste Feed Evaporators. The offgas is condensed based on splits that can be found in Table D-2. Condensates are sent to FEP-VSL-00005A. The offgas that is not condensed is sent to the Pretreatment Vessel Vent Process (PVP) system (PVP-SCB-00002).

Vessel Tag #	Equipment Description
FEP-VSL-00005A	Waste Feed Evaporator Condensate Vessel

The Waste Feed Evaporator Condensate Vessel receives condensate from the demisters. Water, used to model condensate from the vacuum eductors, is also delivered from a steam header to FEP-VSL-00005A at a rate of 0.96 gpm whenever the Waste Feed Evaporator is running. Once it reaches the maximum volume, it empties to RLD-VSL-00006A. FEP-VSL-00005A can always receive condensate unless it is at maximum volume and RLD-VSL-00006A cannot accept feed.

Figure F-4 provides a graphical illustration of the FEP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the FEP.

4.8.3 Ultrafiltration Process (UFP) System

The primary functions of the UFP are to: 1) separate dissolved and undissolved wastes by ultrafiltration, 2) caustic leach aluminum and other undissolved solids if necessary, 3) oxidative leach chromium if necessary, and 4) separate leachate from undissolved solids by washing.

Vessel Tag #	Equipment Description
UFP-VSL-00001A	Ultrafiltration Feed Preparation Vessel
UFP-VSL-00001B	Ultrafiltration Feed Preparation Vessel

The UFP1 vessels receive waste and recycle from the following equipment:

Vessel Tag #	Equipment Description
FRP-VSL-00002A	Waste Feed Receipt Vessel
FRP-VSL-00002B	Waste Feed Receipt Vessel
FRP-VSL-00002C	Waste Feed Receipt Vessel
FRP-VSL-00002D	Waste Feed Receipt Vessel
HLP-VSL-00022	HLW Feed Receipt Vessel
FEP-SEP-00001A	Waste Feed Evaporator (default)

Vessel Tag #	Equipment Description
FEP-SEP-00001B	Waste Feed Evaporator (inactive)
HLP-VSL-00027A	HLW Lag Storage Vessel (UFP1 leaching)
RLD-VSL-00006A	Process Condensate Vessel

Feed blending logic are implemented in the UFP1 vessels to: a) improve the uniformity of ultrafiltration feeds, b) better balance the overall utilization of LAW and HLW feeds, and c) alleviate the pressure of water lock on the recycle loop. Under normal operating conditions, feed blending is performed by filling a UFP1 vessel with a pre-determined volume of HLW feed then topping it off with LAW feed to reach the set volume. The blend ratio is determined based on solid contents of the feeds and the heel, i.e.,

$$V_{HLW} = \left(\frac{(WPCT_{goal} - WPCT_{law}) * V_{set} + (WPCT_{law} - WPCT_{heel}) * V_{min}}{(WPCT_{hlw} - WPCT_{law})} \right) \quad (\text{Eq. 26})$$

$$V_{LAW} = V_{set} - V_{HLW} \quad (\text{Eq. 27})$$

Where:

V_{HLW} = Volume contribution from the HLW feed (gallons)
 V_{LAW} = Volume contribution from the LAW feed (gallons)
 V_{set} = Set volume of UFP1 (18,300 gallons)
 $WPCT_{goal}$ = Feed blending wt % solid goal (7%)
 $WPCT_{law}$ = Current wt % solids of the LAW feed
 $WPCT_{hlw}$ = Current wt % solids of the HLW feed
 $WPCT_{heel}$ = Current wt % solids of the heel in the blend tank

All Tank Farm batches, including LAW and HLW wastes, are limited to solid concentrations less than or equal to 10 wt% solids. Some specific rules are applied to the feed blending operations under off-normal conditions:

If not enough HLW feed is available for blending, e.g., HLP-VSL-00022 is reaching the heel, LAW feed will be used to make up the volume difference after the remaining HLW feed is received. In that case, the wt % solids of the blended feed will be below the 7% target.

In contrast, if not enough LAW feed is available for blending, the vessel will be made available for discharge after the remaining LAW feed is received. In this case, the wt % solids of the blended feed will be above the 7% target, but it prevents the UFP1 vessel from becoming idle when a new LAW batch is received by the FRP from the Tank Farm.

If the wt % solids of the HLW feed is below the 7% target, no blending will be required such that only the HLW feed will be used to fill to the set volume.

Also, if HLW or LAW feeds is not available, the only feed available will be used to fill to the set volume without blending.

Line flush is received in the UFP1 vessel after each batch transfer from HLP-VSL-00022 and FRP-VSL-00002A/B/C/D. To prevent foaming from Pulse Jet Mixer operations, AFA is added immediately after feed blending. AFA is replenished every other 6-hours to make up losses due to decomposition during

pre-heating, storage, and discharge. Target concentrations for PPG and PDMS are discussed in Section 4.7.17.

Steam will also be added to the vessel after feed blending. Vessel contents will be heated to 45 °C with a steam condensate volume and a heating time determined by Equations 28 and 29, respectively.

$$V_s = \frac{2540 * V_w}{49562} \quad (\text{Eq. 28})$$

$$T_H = \frac{3 * V_w}{49562} \quad (\text{Eq. 29})$$

Where:

V_s = Steam condensate volume (gallons)
 V_w = Waste volume before heating (gallons)
 T_H = Heating time (hours)

Solubility is applied at 45 °C after pre-heating. At this point the vessel becomes a priority vessel in receiving evaporator concentrate as discussed in Section 4.8.2, note: this vessel must wait if the alternate UFP1 vessel is currently receiving from the FEP evaporator. The wait time will last until the evaporator has finished the current batch (e.g., the evaporator feed tank becomes empty or the alternate UFP1 reaches the maximum volume), and when the evaporator has feed to start a new batch. During the wait, the UFP1 vessel can also discharge if the downstream UFP2 vessel is available to receive feed.

UFP-VSL-00001A and UFP-VSL-00001B operate in an alternating fashion, e.g., one will not discharge until the other is “empty”. A UFP1 vessel will feed both UFP2 vessels as needed during the saw-tooth operation to support parallel operation of the ultrafilters.

Twice a year, heel dilutions are performed in UFP-VSL-00001A/B to reduce solids concentration in the heel that may have accumulated. Fluids used for dilution are LAW feeds from FRP-VSL-00002A/B/C/D, process condensate, or DIW in preferred orders. The UFP-VSL-00001A/B heel dilutions are scheduled to separate with other heel dilution operations in HLP-VSL-00022 and FEP-VSL-00017A/B. The portable pump connects UFP-VSL-00001A with UFP-VSL-00002A and UFP-VSL-00001B with UFP-VSL-00002B. Heel dilution can only be performed when: 1) the receiving UFP2 vessel is in solids concentration mode, 2) the UFP2B solids have been split to UFP2A, and 3) the receiving UFP2 current solid concentration ≤ 15 wt% solids. These conditions ensure that: 1) unleached solids will not be added to the already leached contents, 2) the receiving UFP2 vessel has enough space for the dilution contents, and 3) heel dilution can be completed in the current UFP2 solids concentration cycle. Refer to Section 4.7.20 for further details on general rules of heel dilution and UFP-VSL-00001A/B specific volume parameters.

Vessel Tag #	Equipment Description
UFP-VSL-00002A	Ultrafiltration Feed Vessel
UFP-VSL-00002B	Ultrafiltration Feed Vessel

The UFP2 vessels and associated ultrafilters are designed to operate in parallel during solids concentration and reconcentration after caustic leach. During solids concentration, the UFP2 vessels receive feed from a UFP1 vessel currently emptying. The UFP1 to UFP2 line is flushed with 480 gallons

of inhibited water at 90 gpm at the end of solids concentration or when the UFP1 vessel reaches the heel. Flush water goes to the receiving UFP2 vessel.

Filter loops are divided into pre-isolation valve and post-isolation valve sections. Filter loop volumes of the pre-isolation valve and post-isolation valve sections are:

UPF-02A-P1 = UFP-02B-P1 = 500 gallons
UFP-02A-P2 = UFP-02B-P2 = 1,576 gallons

The post-isolation valve sections will be filled with 0.1M caustic (NaOH) during startup while the pre-isolation sections will be filled with wastes by drainage in the beginning of each ultrafiltration cycle. Inlets of the pre-isolation valve pipes are situated at the 15,000-gallon level in the UFP2 vessels, meaning that these vessels can only be concentrated to the 15,000-gallon level through the circulation pump. Permeate flux rates through the ultrafilters depend on temperature, weight percent solids, sodium molarity, and effective filter area. The permeate flux rate is calculated using the equations below:

$$F = A_{eff} * O_F * \left[\frac{\exp(0.445 * 5)}{\exp(0.445 * C_{Na})} \right] * \left(\frac{1}{\exp \left[2500 * \left(\frac{1}{T_K} - \frac{1}{298} \right) \right]} \right) \quad (\text{Eq. 30})$$

Where:

F = Filter flux per train (gpm)
A_{eff} = Effective filter area per train (ft²)
C_{Na} = Sodium molarity (gmol/liter)
T_K = Operating temperature (K)
O_F = Operation Factor (gpm/ft²)

For solids concentration and reconcentration:

$$O_F = \frac{2.1e - 4}{X^{1.3}} + 0.112 \quad (\text{Eq. 31})$$

Where:

X = Weight percent solids (kg solids /kg slurry)

For solid wash including wash forward and wash recycle:

$$O_F = 0.012 \quad (\text{Eq. 32})$$

For oxidative wash:

$$O_F = 0.008 \quad (\text{Eq. 33})$$

Effective filter area equals to 1,451 ft² per train, ultrafiltration operates at 45 °C, and upper and lower bounds of the filter flux are set to 115 gpm and 1 gpm, respectively. Flux rate is reduced to 10% of the

filter capacity when both HLP-VSL-00027A/B vessels are filled with treated solids and are unable to receive, this is done to extend the UFP2 cycle time and therefore ease the pressure of recycle production on storage volumes for equipment in the recycle loop.

Two positive displacement pumps connect the UFP2 vessels to the following receiving vessels:

UFP-VSL-00002A → HLP-VSL-00027A (Non-Newtonian)
 UFP-VSL-00002A → HLP-VSL-00027B (Non-Newtonian)
 UFP-VSL-00002A → PWD-VSL-00015 (Newtonian)
 UFP-VSL-00002A → PWD-VSL-00016 (Newtonian)
 UFP-VSL-00002B → HLP-VSL-00027A (Non-Newtonian)
 UFP-VSL-00002B → HLP-VSL-00027B (Non-Newtonian)
 UFP-VSL-00002B → PWD-VSL-00015 (Newtonian)
 UFP-VSL-00002B → PWD-VSL-00016 (Newtonian)

The positive displacement pumps will run at 94 gpm for Newtonian fluids and 55 gpm for Non-Newtonian fluids. The pumps can empty the UFP2 vessels to their minimum volumes of 500 gallons. The downstream vessel will receive 150 gallons of line flush with inhibited water at 90 gpm after a Non-Newtonian fluid transfer. The operation sequence of UFP2 is discussed as follows.

Due to a Mechanical System design change that increases the minimum volume of ultrafilter circulation pump inlet level, a UFP2 double batching operation is introduced that enables: a) reasonable sized solid batches be leached, b) sufficient headspaces are available to support heating and leaching, and c) leached solids can be reconcentrated to target values before discharging. Details of the double batching operation are described as follows:

- 1) Set UFP2A/B maximum volume to 29,900 gallons
- 2) Start solid concentration in UFP2B, sawtooth at high set points between 26,000 - 25,000 gallons, concentration target = 20 wt% solid
- 3) In parallel to the UFP2B solid concentration, do wash forward, wash recycle, oxidative leach, oxidative wash, solid discharge, acid clean in UFP2A (Figures 2a and 2b)
- 4) If UFP2B reaches the concentration target before UFP2A reaches the end of current cycle, hold UFP2B until UFP2A completes all the steps in Figure 2b
- 5) Else if UFP2A reaches the end of current cycle before UFP2B reaches concentration target, stop UFP2B solids concentration
- 6) Transfer half of the UFP2B contents to UFP2A, transfer rate = 94 gpm (feed split, Figure 2c)
- 7) Restart solid concentration in UFP2A/2B, sawtooth at low set points between 16,000 - 15,000 gallons (Figure 2d). Continue solid concentration until both trains reach 20 wt% solid target concentration. Make caustic leach decisions at the same time
- 8) If both UFP2A/2B batches require caustic leach
 - Caustic leach UFP2A/2B (Figure 3e)
 - Reconcentrate UFP2A/2B to 15,000 gallons or 20 wt% solids, whichever comes first (initial recon, Figure 3f)
 - Transfer UFP2B contents (excluding the 500 gallon heel) to UFP2A, transfer rate = 55 gpm (feed combination, Figure 3g)
 - UFP2B goes back to Step 2, do filter clean if required. In parallel, reconcentrate UFP2A to 15,000 gallons or 20 wt% solids, whichever comes first (secondary recon, Figure 3h)
 - UFP2A goes back to Step 3

- 9) Else if both UFP2A/2B batches do not require caustic leach
 - Skip leaching, initial recon, feed combination, and secondary recon steps
 - Wash, oxidative leach, oxidative wash, and discharge solids one train at a time. Start with the UFP2B train (Figure 4i)
 - Do filter clean if required
 - Go back to Step 2
- 10) Else if one train requires caustic leach and another train does not (possibility low)
 - Apply Step 8 processes

The UFP2A/2B trains can operate in parallel during solid concentration, caustic leach, and initial reconcentration. Steam and cooling water supplies can support simultaneous operations.

Figure 2 UFP2 Double Batching Operation (Part 1)

Figure 3 UFP2 Double Batching Operation (Part 2)

Figure 4 UFP2 Double Batching Operation (Part 3)

Solids Concentration

AFA is added immediately after a UFP2 is filled to the set volume with feed from UFP1. Target concentrations for PPG and PDMS are discussed in Section 4.7.17. Solids concentration begins by pumping and filling (sawtooths) the UFP2 vessel between the upper set volume and the lower setpoint, the UFP2 vessel is allowed to receive before it reaches the lower setpoint to ensure an undisrupted ultrafiltration operation. Through the circulation pump, ultrafilter permeate is routed to the Ultrafiltration Permeate Collection Vessel (UFP-VSL-00062A/B/C) while concentrated slurry is returned to the UFP2 vessel. The solids concentration process continues until 20 wt % solids has been reached. Solubility correlations are applied at 45 °C at the peak of the sawtooth during solids concentration. AFA is replenished every 6-hours to make up losses due to decomposition during the remaining UFP2 operations except during oxidative leaching.

Caustic Leach

Generally caustic leach can reduce the HLW glass produced as most of the WTP solids are aluminum limiting. For waste batches that are limited by other Specification 1 species (see bounding condition flags in Figure 5 for details), caustic leach is unnecessary as it increases processing time and adds sodium to the waste. A caustic leach decision logic has been developed by PE that determines if a waste batch is aluminum limiting and consequently if the caustic leach can reduce HLW glass by 10% or more. Wash factors as well as the subsequent oxidative leach are also considered. Figures 5 through 8 provide logic diagrams that are implemented in G2 model, where:

- EG-Majors is the estimated glass amount expected if the glass limited by major glass constituents
- EG-Minors is the estimated glass amount expected if the glass limited by minor glass constituents
- EG-Cr is the estimated glass amount expected if the glass is chromium limited
- BC-*i* is the HLW glass oxide limiting value set in G2 as wt fraction units, not wt%
- LF values are Tank Farm's given leach factor values for corresponding element, units in wt-fraction
- PTWF-C2O4 is a wash factor for solid oxalate in Pretreatment
- PO4-3(Hard) is the insoluble form of phosphate in the batch, kilo-moles
- PO4-3 is the soluble form of phosphate in the batch, kilo-moles
- P_{pf} is an estimated average of the soluble phosphate that will precipitate and report to HLW for vitrification
- OxLF is the oxidative leach factor for chromium
- WF-Ox is the estimated wash factor for removing dissolved chromium and other salts from the batch after oxidative leaching. Presently, three vessel washing are preformed

Details for the development of this caustic leach decisions logic can be found in 24590-WTP-MCR-PET-09-0048.

Figure 5 Caustic Leach Decisions Logic Diagram (Part 1)

Figure 6 Caustic Leach Decisions Logic Diagram (Part 2)

Figure 7 Caustic Leach Decisions Logic Diagram (Part 3)

Figure 8 Caustic Leach Decisions Logic Diagram (Part 4)

The caustic leach decision is made based on UFP2 solids composition at the end of the solids concentration process. If caustic leach is not needed, the current UFP2 vessel will start solid wash, otherwise it will perform the caustic leach operations.

Before caustic leach operations can be performed, the filter loop is power flushed with one filter loop volume of inhibited water (2,076 gallons) which takes 0.183 hours. An 85% flushing efficiency is achieved and the slurry is pushed back into the UFP2 vessel.

Caustic leach operations include heating, reaction, cooling, and re-concentration. A pre-determined volume of 19M NaOH (Na = waste sodium) will be added during heating. Vessel contents will be heated to 85 °C with steam. Condensate volume and heating time are determined by Equations 34 and 35, respectively.

$$V_S = \frac{5000 * (V_W + V_{ACV})}{24500} \quad (\text{Eq. 34})$$

$$T_H = \frac{6 * (V_W + V_{ACV})}{24500} \quad (\text{Eq. 35})$$

Where:

V_S = Steam condensate volume (gallons)
 V_W = Waste volume before heating (gallons)
 V_{ACV} = Average caustic volume (gallons)
 T_H = Heating time (hours)

The average caustic volume (5,359 gallons) is obtained by averaging the values for the entire mission from a trial run. The caustic volume for leaching is determined based on Equation 11 with an additional 10% margin to account for dilution later during wash. The heated solutions are allowed to react for 8 hours. Leaching reactions include:

Reaction	Conversion (Fraction)
$\text{Bi}+3 \text{ (s)} + 3 \text{ OH}^- \text{ (l)} \rightarrow \text{Bi}+3 \text{ (l)} + 3 \text{ OH}^- \text{ (l)}$	Batch dependent
$\text{Ca}+2 \text{ (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow \text{Ca}+2 \text{ (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$\text{Fe}+3 \text{ (s)} + 3 \text{ OH}^- \text{ (l)} \rightarrow \text{Fe}+3 \text{ (l)} + 3 \text{ OH}^- \text{ (l)}$	Batch dependent
$\text{Si}+4 \text{ (s)} + 4 \text{ OH}^- \text{ (l)} \rightarrow \text{Si}+4 \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	Batch dependent
$\text{U(TOTAL)} \text{ (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow \text{U(TOTAL)} \text{ (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$232\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 232\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$233\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 233\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$234\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 234\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$235\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 235\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$236\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 236\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$238\text{-U (s)} + 2 \text{ OH}^- \text{ (l)} \rightarrow 238\text{-U (l)} + 2 \text{ OH}^- \text{ (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (s)} + 3 \text{ OH(BOUND)} \text{ (s)} + \text{OH}^- \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (s)} + 3 \text{ NO}_3^- \text{ (s)} + 4 \text{ OH}^- \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)} + 3 \text{ NO}_3^- \text{ (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (s)} + 3 \text{ NO}_2^- \text{ (s)} + 4 \text{ OH}^- \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)} + 3 \text{ NO}_2^- \text{ (l)}$	Batch dependent
$2 \text{ Cr(TOTAL)} \text{ (s)} + 3 \text{ CO}_3\text{-2 (s)} + 8 \text{ OH}^- \text{ (l)} \rightarrow 2 \text{ Cr(OH)}4^- \text{ (l)} + 3 \text{ CO}_3\text{-2 (l)}$	Batch dependent
$2 \text{ Cr(TOTAL)} \text{ (s)} + 3 \text{ SO}_4\text{-2 (s)} + 8 \text{ OH}^- \text{ (l)} \rightarrow 2 \text{ Cr(OH)}4^- \text{ (l)} + 3 \text{ SO}_4\text{-2 (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (s)} + \text{PO}_4\text{-3 (s)} + 4 \text{ OH}^- \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)} + \text{PO}_4\text{-3 (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (s)} + 4 \text{ OH}^- \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)}$	Batch dependent
$\text{Cr(TOTAL)} \text{ (l)} + 4 \text{ OH(BOUND)} \text{ (l)} \rightarrow \text{Cr(OH)}4^- \text{ (l)}$	1.0
$\text{SO}_4\text{-2 (s)} + 2 \text{ Na}^+ \text{ (s)} \rightarrow \text{SO}_4\text{-2 (l)} + 2 \text{ Na}^+ \text{ (l)}$	Batch dependent
$\text{Na}^+ \text{ (s)} \rightarrow \text{Na}^+ \text{ (l)}$	Batch dependent
$\text{C}_2\text{O}_4\text{-2 (s)} + 2 \text{ Na}^+ \text{ (s)} \leftrightarrow \text{C}_2\text{O}_4\text{-2 (l)} + 2 \text{ Na}^+ \text{ (l)}$	Solubility driven
$\text{PO}_4\text{-3 (s)} + 3 \text{ Na}^+ \text{ (s)} \leftrightarrow \text{PO}_4\text{-3 (l)} + 3 \text{ Na}^+ \text{ (l)}$	Solubility driven
$\text{Al(OH)}_3 \text{ (s)} + \text{OH}^- \text{ (l)} \leftrightarrow \text{Al(OH)}_4^- \text{ (l)}$	Solubility driven

Leach factors for the reactions are provided in the feed vector and vary from batch to batch. Due to feed blending and recycle operations, a single set of leach factor values from the Tank Farm is no longer

representative to the mixed wastes, and weighted average values are calculated as wastes are transferred downstream.

$$DLF_i = \frac{(ULF_i * UCM_i + DLF_i^o * DCM_i^o)}{(UCM_i + DCM_i^o)} \quad (\text{Eq. 36})$$

Where:

DLF_i	= Updated downstream leach factor for component i (fraction)
ULF_i	= Upstream leach factor for component i (fraction)
UCM_i	= Upstream mass for component i (kg-moles)
DLF_i^o	= Initial downstream leach factor for component i (fraction)
DCM_i^o	= Initial downstream mass for component i (kg-moles)

The leach factors are tracked from the Tank Farm to FRP-VSL-00002A/B/C/D, HLP-VSL-00022, UFP-VSL-00001A/B, and UFP-VSL-00002A/B vessels. It is assumed that solids in the recycle streams have already been caustic and/or oxidative leached, for example, solids from the PWD and FEP systems will not contribute to the weighted average leach factor calculation.

Reactions could be reactant limiting, and under such circumstances, the desired reaction extent will not be achieved. The Cr(Total) dissolution reactions take place in the order listed and stop when the Tank Farm leach factor has been reached, in other words, some of the listed chromium reactions may not be required. Gibbsite leaching is handled by the aluminum solubility equation (Eq. 12) at 45 °C. Oxalate and phosphate solubility correlations are also applied at the end of the reactions to ensure phase equilibrium. It is noted that the sodium dissolution reaction may not reach its desired leach factor as the G2 model enforces the sodium oxalate and sodium phosphate bounds in the solid phase. Vessel contents will be cooled to 45 °C, cooling takes 22 hours. Steam and chill water can be used for simultaneous heating or cooling both UFP2 trains.

UFP2 vessel contents will be re-concentrated to 20 wt % solids after cooling. Permeate from the re-concentration operation will be routed to the Supertank (UFP-VSL-00062A). For waste batches with large leachable solids, the 20 wt % solids re-concentration target may not be reached as the filter loop circulation pump limits the UFP2 minimum level to 15,000 gallons. Reconcentrated feeds in UFP2B will be transferred to UFP2A for secondary reconcentration.

Generally oxidative leach can reduce the HLW glass produced if the solids are chromium limiting. For waste batches that are limited by other Specification 1 species, oxidative leach is unnecessary as it increases processing time and adds sodium and manganese to the waste via the use of sodium permanganate. Similar to the caustic leach decisions discussed previously, an oxidative leach decision logic has been developed by PE that determines if a waste batch is chromium limiting and consequently if the oxidative leach can reduce HLW glass by 10% or more. Figures 9 through 11 provide logic diagrams that are implemented in the G2 model. Details for the development of this oxidative leach decisions logic can be found in 24590-WTP-MCR-PET-09-0049.

Figure 9 Oxidative Leach Decisions Logic Diagram (Part 1)

Figure 10 Oxidative Leach Decisions Logic Diagram (Part 2)

Figure 11 Oxidative Leach Decisions Logic Diagram (Part 3)

The oxidative leach decision is made based on UFP2 vessel contents at the end of re-concentration as this decision will also impact how solid wash will be performed.

Solid Wash

Solid wash is achieved by pumping and filling the UFP2 vessel with process condensate (primary source) or process water (secondary source) in 1000-gallon increments based on the following scenarios:

- 1) If caustic leach is skipped, sawtooth between 16,000 and 15,000 gallons
- 2) If caustic leach is performed and re-concentration reaches 20 wt % solids, sawtooth between the volume at 20 wt % solids (V_R) and $V_R + 1000$ gallons
- 3) If caustic leach is performed and re-concentration could not reach 20 wt% solids, sawtooth between 16,000 and 15,000 gallons

UFP2 filling rates are 250 gpm with process condensate and 73 gpm with water.

Solid wash is divided into two stages: 1) wash forward, and 2) wash recycle. Permeate is routed to the UFP-VSL-00062 vessels during wash forward and to the PWD-VSL-00015/16 vessels during wash recycle. Wash volumes depend on waste conditions at the end of solids concentration or re-concentration and if subsequent oxidative leach is required. The minimum volume for wash recycle is 1,000-gallons.

If subsequent oxidative leach is required:

- Total wash volume is set to wash until $[\text{OH}^-]$ reaches 0.25M
- Permeate will be fed forward if all of the following are true:
 - $[\text{Na}^+] \geq 3.8\text{M}$, and
 - $[\text{Na}^+] \geq 0.5 * \text{sodium concentration at end of solids concentration}$, and
 - $[\text{PO}_4\text{-}3] \geq 0.4 * \text{peak phosphate concentration}$, and
 - $[\text{C}_2\text{O}_4\text{-}2] \geq 0.4 * \text{peak oxalate concentration}$
- Permeate will be recycled until $[\text{OH}^-] \leq 0.25\text{M}$
- Wash recycle may or may not be needed, depending on the wash forward volume, e.g., skip wash recycle if wash forward volume equals to total wash volume

If subsequent oxidative leach is not required:

- $2.8 * V_{\text{slurry}} \leq \text{total wash volume} \leq V_{\text{max}}$
- Wash forward if all of the following are true:
 - $[\text{Na}^+] \geq 3.8\text{M}$, and
 - $[\text{Na}^+] \geq 0.5 * \text{sodium concentration at the end of re-concentration}$, and
 - $[\text{PO}_4\text{-}3] \geq 0.4 * \text{peak phosphate concentration}$, and
 - $[\text{C}_2\text{O}_4\text{-}2] \geq 0.4 * \text{peak oxalate concentration}$
- Permeate will be recycled until total wash volume has been applied
- Skip wash recycle if wash forward volume equals to total wash volume

Where:

V_{slurry} = Slurry volume at the end of solids concentration (gal)
 V_{max} = Maximum wash volume (gal)

Peak concentrations are defined as the highest dissolved phase oxalate and phosphate concentrations achieved during wash. It is not necessarily true that peak concentrations occur at the beginning of wash. In fact, dissolve phase oxalate and phosphate concentrations decline initially, then spike, and finally recede. This phenomenon occurs for batches with reasonable solid phase oxalate and phosphate at the beginning of wash, due to dilution and dissolution.

If the current batch is not phosphate limiting,

$$V_{\text{max}} = \text{least of } \{(4.5 * V_{\text{slurry}}), (0.25\text{M } [\text{OH}^-])\}$$

otherwise

$$V_{\text{max}} = \text{least of } \{(4.5 * V_{\text{slurry}}), (0.25\text{M } [\text{OH}^-]), (0.1 * \text{peak } [\text{PO}_4\text{-}3])\}$$

The following method is applied to determine if the current batch will form phosphate limiting IHLW glass.

$$\text{EG-P} = (\text{PO4-3(HARD)} + \text{PO4-3(s)} + \text{PO4-3(l)}) * 70.97 / \text{FLAG-P2O5} \quad \text{Eq. (37)}$$

$$\begin{aligned} \text{EG-O} = \text{MAX} (& \\ & \text{Fe+3} * 79.84 / \text{MAX}(\text{FLAG-FE2O3}, 0.1375), \\ & \text{Zr+4} * 123.22 / \text{FLAG-ZrO2}, \\ & \text{U(Total)} * 270.03 / \text{FLAG-UO3}, \\ & \text{Th+4} * 265.03 / \text{FLAG-ThO2}, \\ & \text{Ca+2} * 56.08 / \text{FLAG-CaO}, \\ & \text{Ni+2} * 74.69 / \text{FLAG-NiO}, \\ & \text{Pb+2} * 223.19 / \text{FLAG-PbO2}, \\ & \text{Bi+3} * 232.97 / \text{FLAG-Bi2O3}, \\ & \text{F-} * 18.99 / \text{FLAG-F}, \\ & \text{SO4-2} * 80.06 / \text{FLAG-SO3}, \\ & (\text{Na+} - (2 * \text{C2O4-2(s)} * \text{PTWF-C2O4})) * 30.99 + \text{K+} * 47.09) / \text{FLAG-Na2O}, \\ & (\text{AlOH3} + \text{Al+3(s)}) * 50.98 / \text{FLAG-Al2O3}, \\ & (\text{Cr(Total)} + \text{Cr+3(l)}) * 75.99 / \text{FLAG-Cr2O3}, \\ &) \end{aligned} \quad \text{Eq. (38)}$$

Where:

EG-P = The estimated glass produced from phosphate (kg)

EG-O = The estimated glass produced from other wastes in solids (kg)

Individual element quantities (i.e., Fe+3) units are in kg-mole

FLAG-“x” is the HLW glass limiting oxide value set in G2 as wt fraction units

Multiplier values are in kg oxide / kg-mole element

PTWF-C2O4 is a wash factor for solid oxalate in Pretreatment

If $\text{EG-P} \geq 1.01 * \text{EG-O}$ and $\text{PO4-3 (s)} > 0.01 * \text{PO4-3(HARD) (s)}$ then
phosphate limited glass = true

else

phosphate limited glass = false

To ensure phase equilibrium, solubility corrections are applied at 45 °C during wash. It is important to note that oxalate and phosphate tend to dissolve as wash progresses when aqueous phase sodium is washed out, but aluminate tends to precipitate as hydroxide concentration also goes down. Section 4.7.16 states that it is desirable to send more of the soluble constituents to the LAW Facility with the goal of keeping a balance among the WTP mission, IHLW glass production, solids reprecipitation and line plugging factors.

To prevent aluminum precipitation, 19M NaOH (Na = waste sodium) is added to the UFP2 vessel during wash until the current aluminate concentration is less than / equal to 8% of its concentration at end of solids concentration or re-concentration, e.g., 92% of the aluminate has been washed out. The caustic is added on an as needed basis to keep aluminate unsaturated. Further discussions are provided later in this section for the sodium dilution and caustic addition operations in UFP-VSL-00062 to prevent solids precipitation.

Slurries will be concentrated to 20 wt % solids if possible at the end of the wash. For batches not requiring oxidative leach, skip to solid discharge.

Oxidative Leach

The oxidative leach decision is made at the end of solids concentration or re-concentration. If “true”, the solid wash operations above will continue until $[\text{OH}^-] \leq 0.25\text{M}$ is achieved. It is known that oxidative leach is most effective when $0.2\text{M} \leq [\text{OH}^-] \leq 0.25\text{M}$. The G2 model implements a caustic addition operation such that enough caustic (2M NaOH) can be added to bring up the $[\text{OH}^-]$ concentration if it is below 0.2M. Sodium permanganate (1M NaMnO₄) will be added to further dissolve chromium during oxidative leach. The volume of sodium permanganate added is based on a Mn to Cr(Total) ratio equals to 1.1. Side reactions will take place that dissolve fractions of the plutonium and its isotopes. Oxidative leach reactions will take 6 hours to complete during which the recirculation loop will be run to enhance mixing, which also results in the contents of the loop being leached. Chromium, plutonium and its isotopes are leached according to the following reactions.

Reaction	Conversion (Fraction)
$\text{Cr(Total)} (s) + 3\text{OH(Bound)} (s) + \text{Mnp} (l) + 4\text{O-2} (l) + \text{OH-} (l) \rightarrow \text{Cr(Total)} (l) + 4\text{O-2} (l) + \text{Mnp} (s) + 2\text{O-2} (s) + 2\text{H}_2\text{O} (l)$	0.876 ^{a)}
$\text{Cr(Total)} (s) + \text{Mnp} (l) + 4\text{O-2} (l) + 4\text{OH-} (l) \rightarrow \text{Cr(Total)} (l) + 4\text{O-2} (l) + \text{Mnp} (s) + 2\text{O-2} (s) + 2\text{H}_2\text{O} (l)$	variable ^{b)}
$\text{Mnp} (l) + 4\text{O-2} (l) \rightarrow \text{Mnp} (s) + 2\text{O-2} (s) + 2\text{O-2} (l)$	1.0 ^{c)}
$238\text{-Pu} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow 238\text{-PU} (l) + 4\text{OH-} (l)$	0.01
$239\text{-Pu} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow 239\text{-PU} (l) + 4\text{OH-} (l)$	0.01
$240\text{-Pu} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow 240\text{-PU} (l) + 4\text{OH-} (l)$	0.01
$241\text{-Pu} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow 241\text{-PU} (l) + 4\text{OH-} (l)$	0.01
$242\text{-Pu} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow 242\text{-PU} (l) + 4\text{OH-} (l)$	0.01
$\text{Pu+4} (s) + 3\text{OH(Bound)} (s) + \text{OH-} (l) \rightarrow \text{PU+4} (l) + 4\text{OH-} (l)$	0.01

Notes:

^{a)} Conversion reaches 0.876 if the batch is not OH(Bound) limiting.

^{b)} Needed only if OH(Bound) is limiting.

^{c)} Remaining permanganate is 100% oxidized.

AFA will not be added during oxidative leaching. Existing PPG and PDMS will decompose to DPPG and DPDMS completely.

Oxidative Wash

AFA will be added immediately after oxidative leaching and replenished every other 6-hours until the end of the current UFP2 cycle. Target concentrations for PPG and PDMS are discussed in Section 4.7.17. Oxidative wash is achieved by pumping and filling the UFP2 vessel with process condensate (primary source) or process water (secondary source) in a 1000-gallon increment in a region between the volume at the end of oxidative leach (V_{OX}) and $V_{\text{OX}} + 1000$ gallons. UFP2 filling rates are 250 gpm with process condensate and 73 gpm with water. Wash volume is either $2 \times V_{\text{slurry}}$ or $3 \times V_{\text{slurry}}$ as determined when the oxidative leach decisions are made. Permeate is routed to the PWD-VSL-00015 and PWD-VSL-00016 vessels. Solubility corrections are applied at 45 °C during oxidative wash. Slurries will be concentrated to 20 wt % solids at the end of oxidative wash if possible.

Solid Discharge

Concentrated solids will be discharged to the HLP-VSL-00027A/B vessels with the positive displacement pumps. At the end of solid discharge, e.g., vessel volume = 500 gallons, the filter loop is power flushed with 2,076 gallons of inhibited water. Flushing efficiency equals to 0.85, e.g., 85% of the slurry in the loop are displaced by the flush solution. Contents from the loop go back to the UFP2 vessel. The power flush operation takes 0.183 hours.

Contents of the UFP2 vessel (Non-Newtonian fluids) from the power flush operation will be ejected to HLP-VSL-00027A/B again by the positive displacement pumps. The transfer line is flushed with 150 gallons of inhibited water at 90 gpm after the displacement pumping. Contents of the filter loop including the pre-isolation and post-isolation valve sections are drained to PWD-VSL-00033 at 50 gpm.

Acid Clean

Ultrafilters will be acid cleaned after 500 hours of operation i.e., cumulative usage that excludes idle times, or after every four UFP2 cycles, whichever comes first (note: the filters will continue to be used if the UFP2 vessel has not finished wash). At the end of solid discharge, e.g., after the first power flush operation described above, the filter loop will be power flushed with 2,076 gallons of inhibited water a second time. Flushing efficiency equals to 0.85, e.g., 85% of the slurry in the loop are displaced by the flush solution. Contents from the loop go back to the UFP2 vessel. The power flush operation takes 0.183 hours.

Contents of the UFP2 vessel (Non-Newtonian Fluids) from the power flush operation will be transferred to HLP-VSL-00027A/B by the positive displacement pumps. The transfer line is flushed with 150 gallons of inhibited water at 90 gpm after the displacement pumping. Contents of the filter loop including the pre-isolation and post-isolation valve sections are drained to PWD-VSL-00033 at 50 gpm.

The UFP2 vessel will be filled with 17,076 gallons of 2M nitric acid which will then be circulated in the loop for 1.5 hours. The acid clean solutions (Newtonian Fluids) will be transferred to PWD-VSL-00015/16 with the positive displacement pump.

Contents of the filter loop including the pre-isolation and post-isolation valve sections are drained to PWD-VSL-00033 at 80 gpm. Remaining acidic contents in the UFP2 vessel will be neutralized with 50 gallons of 19M caustic (NaOH) based on the reaction below:

After acid neutralization, the UFP2 vessel will be available to start the next cycle.

Vessel Tag #	Equipment Description
UFP-VSL-00062A	Ultrafiltration Permeate Collection Vessel - Supertank combines UFP-VSL-00062A/B/C and CXP-VSL-00004 operations

G2 model version 7.0 implements a WTP design modification that mitigates solids precipitation for feeds to the ion exchange columns (IXC). In this design modification ultrafiltration permeates are routed to the Permeate Collection Vessels (UFP-VSL-00062A/B/C), then to CXP-VSL-00004. Wash recycle and oxidative wash permeates are routed directly to PWD-VSL-00015 and PWD-VSL-00016. CXP-VSL-00004 will discharge to the IXC through a guard filter (CXP-FILT-00001).

Permeate exiting CXP-FILT-00001 will be split into two streams, one is fed forward to the IXC while the other is recycled through a heat exchanger. The stream through the heat exchanger will be split again, one part goes directly to CXP-VSL-00004 and another part to UFP-VSL-00062A/B/C. The recycle operation mixes the UFP-VSL-00062A/B/C and CXP-VSL-00004 contents to virtually identical compositions and same temperature, as a result, a “Supertank” is created in the model to represent this group-of-four vessels.

The Supertank which combines the working volumes of UFP-VSL-00062A/B/C and CXP-VSL-00004 receives solids concentration, reconcentration, and wash forward permeates and discharges directly to the guard filter. When the ultrafilter trains are working in parallel, both permeate streams are placed in the “Super Tank” at the same time. It operates at 50 °C in a continuous mode (although solubilities are applied at 45 °C due to lack of data for correlation curve fits), meaning that it can receive and discharge at the same time. The Supertank is named after the UFP-VSL-00062A vessel with the following working volumes:

$$\begin{aligned} V_{\min} &= 11,755 \text{ gallons} \\ V_{\text{set}} &= 11,800 \text{ gallons} \\ V_{\max} &= 78,775 \text{ gallons} \end{aligned}$$

A headspace (15,000 gallons) is reserved for the sodium dilution and caustic addition operations below and the ion exchange displacement operations in Section 4.8.4.

Sodium Dilution

The feed to CXP must meet a maximum sodium concentration target. Process condensate (primary source) or process water (secondary source) will be added for dilution if sodium concentration in the vessel is greater than 8M. Filling rates are 250 gpm with process condensate and 73 gpm with water. Volumes for dilution vary from batch to batch depending on conditions of the ultrafilter permeates as well as the caustic addition operations below. Dilution will continue until $[\text{Na}^+] \leq 8\text{M}$ or the maximum volume of the vessel has been reached.

Process condensate or process water will also be added to prevent oxalate and phosphate precipitation. The volume of water added is determined to ensure that dissolved $\text{C}_2\text{O}_4^{2-}$ and PO_4^{3-} are unsaturated or at equilibrium.

Caustic Addition

Aluminate tends to precipitate when OH^- concentration is diluted as the result of sodium dilution above. Provided that the maximum volume of vessel is not reached, enough caustic (19M NaOH, defined as waste sodium) will be added to prevent the following reaction from taking place:

This caustic addition may increase the sodium concentration to above the 8M target value.

An iterative approach is taken to continue the sodium dilution and caustic addition operations until sodium concentration $\leq 8\text{M}$ and $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} , and $\text{Al}(\text{OH})_4^-$ do not precipitate or the maximum volume of the vessel is reached. Because the “Super Tank” is modeled as a continuous tank, dilution and caustic addition are evaluated continuously when it is running.

The Supertank discharges to the ion exchange columns through CXP-FILT-00001 at a fixed flow rate at 30 gpm.

Figure F-5 provides a graphical illustration of the UFP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the UFP.

4.8.4 Cesium Removal Using Ion Exchange Process (CXP) System

The purpose of the Cesium Ion Exchange System is to remove cesium (Cs-134, Cs-137, and Cs+) that is in the solution. Because cesium is soluble, it cannot be removed by ultrafiltration and an ion exchange (IX) process is used. These elements need to be removed to meet LAW vitrification shielding and glass product requirements, and are sent to the HLW melter.

Vessel Tag #	Equipment Description
CXP-VSL-00004	Cesium Ion Exchange Caustic Rinse Collection Vessel
CXP-FILT-00001	Cesium Ion Exchange Guard Filter

The WTP has implemented design changes that remove CXP-VSL-00001 from the flowsheet, utilize CXP-VSL-00004 as the cesium ion exchange feed vessel, utilize CXP-VSL-00005 to supply caustic for IX displacement, add heating and recycling equipment for mixing of ion exchange feeds, and add an in-line guard filter between CXP-VSL-00004 and the IX columns (see Figure F-8 for illustration). The Cesium Ion Exchange Caustic Rinse Collection Vessel now receives feeds from UFP-VSL-00062A, UFP-VSL-00062B, and UFP-VSL-00062C. One main objective of the heating and recycling operations is to mix permeate from various UFP2 operations such as solids concentration, reconcentration, and wash forward in the group-of-four vessels. For modeling simplicity, the group-of-four vessels are combined into a large vessel called “Super Tank”. For details of the “Super Tank” operations, refer to Section 4.8.3.

Feeds to the IX columns from the Super Tank are routed through CXP-FILT-00001. The CXP-FILT-00001 filter housing has a 117-gallon holding capacity. The filter housing is empty before startup and after each back flush operation. It is assumed that 100% of the solids from the Super Tank is captured by CXP-FILT-00001. It is anticipated that filter cakes need to be removed by the back flush operations after 34 UFP2 batches have been processed (here a UFP2 batch is defined as the completion of a solids concentration cycle by an ultrafiltration train).

During model runs, the current-batch attribute of CXP-FILT-00001 increments after each UFP2 batch is processed. A filter back flush analyzer logic procedure keeps track of the current-batch value continuously. When current-batch reaches the target at 34, a back flush operation is triggered. During a back flush, all the liquid and solid in CXP-FILT-00001 are transferred to PWD-VSL-00016, along with 80 gallons of 0.1M NaOH. The back flush operation takes 0.25 hours. The transfer is made as long as PWD-VSL-00016 has sufficient storage to receive, regardless if the vessel is currently in receive or discharge mode. pH adjustment will not be made in PWD-VSL-00016 after a transfer if it receives in discharge mode due to the use of diluted caustic for back flush.

At the end of a back flush, the back flush clock starts to tick. If 24 hours have elapsed and current-batch is still at 34 (e.g., UFP2 has not finished the current solids concentration cycle), then a second back flush will be performed. This 24-hour interval back flush continues until current-batch do not equal to 34 (current-batch is reset to 0 at the end of batch 34).

Vessel Tag #	Equipment Description
CXP-IXC-00001	Cesium Ion Exchange Column
CXP-IXC-00002	Cesium Ion Exchange Column
CXP-IXC-00003	Cesium Ion Exchange Column
CXP-IXC-00004	Cesium Ion Exchange Column

The cesium ion exchange columns operate in carousel patterned cycles such that the loading columns are in “lead”, “lag”, and “polishing” positions while the regenerating column goes through displacement, pre-elution rinse, elution, post-elution rinse, and regeneration. Once the loading is completed, the lead column enters regeneration, the lag column becomes the lead, the polishing column becomes the lag, and the regenerating column becomes the polishing column.

Each column consists of a 600-gallon resin bed and a 480-gallon headspace. The headspace is initially filled with regeneration solutions (0.5M NapOH). It is assumed that plug flow occurs within the resin bed region while mixing can occur in the headspace.

Feed from the in-line guard filter is routed through the loading columns in the lead, lag, and polishing order. The feed pump runs at a fixed flow rate at 30 gpm. In the beginning of each loading cycle, 1,500 gallons, e.g., 2.5 column volumes (cv) of ion exchange effluent will be recycled to the supertank from the polishing column. After that, treated waste from the polishing column is sent to CXP-VSL-00026A, CXP-VSL-00026B, and CXP-VSL-00026C. Overall cesium removal efficiency of the loading columns equals to 99.9766%. For modeling purpose, it is assumed that ion exchange only occurs within the lead column. Loading volume is determined based on the cesium and potassium concentrations of the feed at the start of a cycle (Equations 39, 40, and 41).

$$A = 55214 - 80312 \times [K+] \quad \text{Eq. (39)}$$

$$B = 342375 - 553228 \times [K+] \quad \text{Eq. (40)}$$

$$V_{\text{load}} = -A \times \ln([Cs+]) - B \quad \text{Eq. (41)}$$

Where:

- A = Constant (gallons)
- B = Constant (gallons)
- [K+] = Waste feed potassium concentration (gmol/L)
- [Cs+] = Waste feed overall cesium concentration (gmol/L)

The loading cycle may terminate before V_{load} is reached if cumulated radioactivity contributed by 137-Cs reaches 75,000 curries.

The resin bed is packed with Spherical Resorcinol-Formaldehyde Resin (RF) that is saturated with process sodium (Nap⁺) initially and during regeneration. At saturation the column contains 4.63 kg-moles sodium which is equivalent to 6.8 mmole/g dry H-form resin. Ion exchange takes place where cesium and potassium ions replace the sodium ion during the loading cycle.

Where:

$\{R\}$ = RF resin (inert)

For every kg-mole of ${}^{134}\text{-Cs}$, ${}^{137}\text{-Cs}$, ${}^{137}\text{m-Ba}$, Cs^+ and K^+ captured during ion exchange, 1 kg-mole of Nap^+ is released from the resin surface. The mass balances of the ion exchange within the lead column are given below:

Start of Loading Cycle

$\text{Loading_Nap}^+ = 4.63 \text{ kg-moles/column}$
 $\text{Loading_Cs134} = 0.0 \text{ kg-moles/column}$
 $\text{Loading_Cs137} = 0.0 \text{ kg-moles/column}$
 $\text{Loading_Cs}^+ = 0.0 \text{ kg-moles/column}$
 $\text{Loading_mBa137} = 0.0 \text{ kg-moles/column}$
 $\text{Loading_K}^+ = 0.0 \text{ kg-moles/column}$

End of Loading Cycle

$\text{Loading_Cs134} = 0.999766 \times \text{Cs134_Input}$
 $\text{Loading_Cs137} = 0.999766 \times \text{Cs137_Input}$
 $\text{Loading_Cs}^+ = 0.999766 \times \text{Cs}^+_Input$
 $\text{Loading_mBa137} = 1.526\text{e-}7 \times \text{Loading_Cs137}$
 $\text{Loading_K}^+ = 100 \text{ percent removal until the end of loading cycle or } Q_K \text{ (Eq. 48) reaches Loading_Nap}^+ = 4.63 - \text{Loading_Cs134} - \text{Loading_Cs137} - \text{Loading_Cs}^+ - \text{Loading_K}^+$

The cesium loadings are determined based on the actual cesium input to the lead column from the Supertank. The Q_{Cs} in Eq. 45 is not used as the value is estimated using the concentrations of cesium and hydroxide at the start of the loading cycle. This guarantees that the target removal efficiency can be achieved for the entire loading cycle.

Potassium is captured at a 100% removal efficiency until the end of loading cycle or the maximum loading for K^+ is reached whichever comes first. Q_K is calculated as follows:

$$F_{\text{NaHR}} = \frac{\left(\frac{K_w}{[\text{OH}^-]} \right) \left(\frac{1}{K_{a2}} \right)}{\left[1 + \left(\frac{K_w}{[\text{OH}^-]} \right) \left(\frac{1}{K_{a2}} \right) + \left(\frac{K_w}{[\text{OH}^-]} \right)^2 \left(\frac{1}{K_{a1} K_{a2}} \right) \right]} \quad \text{Eq. (42)}$$

$$F_{\text{Na2R}} = \frac{1}{\left[1 + \left(\frac{K_w}{[\text{OH}^-]} \right) \left(\frac{1}{K_{a2}} \right) + \left(\frac{K_w}{[\text{OH}^-]} \right)^2 \left(\frac{1}{K_{a1} K_{a2}} \right) \right]} \quad \text{Eq. (43)}$$

$$F_{SA} = \frac{F_{NaHR} + 2F_{Na2R}}{2} \quad \text{Eq. (44)}$$

$$Q_{Cs} = \frac{\xi_{Cs} [Cs+] V_{load}}{\rho_{bed} V_{bed}} \quad \text{Eq. (45)}$$

$$\frac{Q_K}{Q_{Na}} = (1.52) \left(\frac{[K+]}{[Na+]} \right)_{Waste}^{0.696} \quad \text{Eq. (46)}$$

$$Q_{Na} = \frac{(F_{SA} Q_{total} - Q_{Cs})}{\left(\frac{Q_K}{Q_{Na}} + 1 \right)} \quad \text{Eq. (47)}$$

$$Q_K = (F_{SA} Q_{total} - Q_{Cs} - Q_{Na}) * 2271 * 0.3 / 1000 \quad \text{Eq. (48)}$$

Where:

K_{a1}	$= 10^{-10.6} \text{ (gmol/L)}$
K_{a2}	$= 10^{-13.2} \text{ (gmol/L)}$
K_w	$= 10^{-14} \text{ (gmol}^2\text{/L}^2\text{)}$
V_{load}	$= \text{Calculated using Eq. 41}$
ξ_{Cs}	$= \text{Cesium removal efficiency (0.999766)}$
F_{SA}	$= \text{Resin disassociation constant (unitless)}$
ρ_{bed}	$= 0.3 \text{ (kg H-form resin/L wet Na-form resin)}$
V_{bed}	$= 2271 \text{ (L)}$
Q_{total}	$= 6.8 \text{ (mmol/g dry H-form resin)}$

[OH-], [134-Cs], [137-Cs], [Cs+], [K+], and [Na+] are concentrations of feed at the start of a loading cycle.

At the end of a loading cycle, resins are regenerated following the steps below:

- 1) Displacement
- 2) Resin outlet flush #1
- 3) Pre-elution rinse
- 4) Elution
- 5) Resin outlet flush #2
- 6) Post-elution rinse
- 7) Resin outlet flush #3
- 8) Regeneration
- 9) Regeneration fluid displacement
- 10) Resin outlet flush #4

The displacement cycle is performed in order to prevent aluminum precipitation during the pre-elution rinse cycle. During the displacement cycle, 0.1M NaOH that comes from CXP-VSL-00005 is routed through the column to displace the pore liquids. Three column volumes of fluid are processed through the

column at a rate of 3 CV/hr. The displaced solution is routed to the Supertank. At the end of displacement, the lead column outlet is flushed the first time with 21 gallons of demineralized water. The outlet is flushed at 30 gpm flow rate and is routed to the Supertank.

The pre-elution rinse cycle is performed in order to prevent acidic eluant solution from reacting during elution with caustic waste solution residing in the column. During the pre-elution rinse cycle, demineralized water from a chem-add is routed to the column to remove the pore liquids. Two CV of DIW are processed at a rate of 3 CV/hr. The exiting material is routed to PWD-VSL-00015 or PWD-VSL-00016, depending on their availability. After 2 CV of pre-elution rinse DIW is processed, the elution cycle starts.

During the elution cycle, 15 CV of 0.45M HNO₃ from the Cesium Evaporator Recovered Nitric Acid Vessel (CNP-VSL-00004) is routed to the column at a rate of 1 CV/hr. Ion exchange takes place where hydrogen ions replace cesium, potassium, and sodium ions. Ion exchange rates are charge balanced and assumed to be linear throughout the elution cycle.

For every kg-mole of H⁺ captured, 1 kg-mole of ¹³⁴-Cs, ¹³⁷-Cs, Cs⁺, ^{137m}-Ba, K⁺, and Nap⁺ is released from the resin surface. The exiting material goes to CNP-EVAP-00001. At the end of elution, the lead column outlet is flushed the second time with 21 gallons of 0.45M HNO₃. The outlet is flushed at 30 gpm flow rate and is routed to CNP-EVAP-00001.

The post-elution rinse cycle is performed in order to prevent caustic waste solution from reacting with acidic eluant solution residing in the column. During the post-elution rinse cycle, DIW is routed to the column to rinse off the pore liquids. Two and a half CV of DIW are processed at a rate of 1 CV/hr. The rinse material is routed to CNP-EVAP-00001. At the end of post-elution rinse, the lead column outlet is flushed the third time with 21 gallons of 0.5M NapOH. The outlet is flushed at 30 gpm flow rate and is routed to CNP-EVAP-00001.

During the regeneration cycle, 4.292 CV of 0.5M NapOH from a chem-add is fed to the column at a rate of 2.78 CV/hr. Ion exchange takes place where sodium ions replace the hydrogen ions.

For every kg-mole of Nap⁺ captured, 1 kg-mole of H⁺ is released from the resin surface. The exiting material goes to PWD-VSL-00015 or PWD-VSL-00016, depending on their availability.

A regeneration displacement is performed after the regeneration cycle. This is accomplished by diverting the treated LAW products from the current polishing column outlet to the regeneration column. A total of 1,250 gallons of treated LAW will be pumped through the regeneration column with the first 1,050 gallons routed to the available PWD-VSL-00015/16 at 0.94 CV/hr and the remaining 200 gallons routed to "Super Tank" at 1.5 CV/hr. A fourth resin outlet flush is performed at the end of regeneration displacement. This is accomplished by expanding the second part of the regeneration displacement with additional 54 gallons of treated LAW. The exiting material is routed to the "Super Tank" at 1.5 CV/hr.

At the end of the last resin outlet flush, the treated LAW is switched back to the CXP-VSL-00026A/B/C vessel currently available while the regeneration column must wait another 0.5 hours before it can be put on line for the next loading cycle. With the regeneration steps complete, the column is placed in stand-by until the “lead” column is ready for regeneration.

After a column has gone through the regeneration process 40 times, the resin must be changed out and two extra steps are added. In the first step, 7,500 gallons of resin transfer solution is used to flush the spent resin out of the regenerating column. The makeup of the resin transfer solution is discussed in Section 4.8.6. The spent resin, along with 7,085 gallons of transfer solution, is pumped to RDP-VSL-00002B while the remaining solution is delivered to RDP-VSL-00002A. In the second step, 1,140 gallons of fresh resin transfer solution is pumped through the regenerating column from CRP-VSL-00001. The fresh resin is deposited in the column while the transfer solution is sent to RDP-VSL-00002A. Further details regarding the fresh resin preparation and spent resin disposal are discussed in Sections 4.8.6 and 4.8.7, respectively.

Chemical reagent concentrations and effluent dispositions for the regenerating steps are presented in Table 14 and the ion exchange operating parameters are summarized in Table 15.

Table 14 Chemical Reagents for Resin Regeneration

Cycles	Reagents	Concentrations	Effluent Disposition
Displacement	NapOH	0.1M	Supertank
Pre-Elution Rinse	DIW	N/A	PWD-VSL-00015/16
Elution	HNO ₃	0.45M	CNP-EVAP-00001
Post-Elution Rinse	DIW	N/A	CNP-EVAP-00001
Regeneration	NapOH	0.5M	PWD-VSL-00015/16
Regeneration Displacement - Part 1	Treated LAW	N/A	PWD-VSL-00015/16
Regeneration Displacement - Part 2	Treated LAW	N/A	Supertank

Table 15 Ion Exchange Operating Parameters

Parameter	Value
Column Headspace Volume (gallons)	480
Column Volume (gallons)	600
Loading Volume (cv)	Min (Eq. 41, cumulated radioactivity $\geq 75,000$ curries)
Loading Rate (cv/hr)	variable (0.5 - 4.5)
Displacement Volume (cv)	3
Displacement Rate (cv/hr)	3
Pre-Elution Rinse Volume (cv)	2
Pre-Elution Rinse Rate (cv/hr)	3

Parameter	Value
Elution Volume (cv)	15
Elution Rate (cv/hr)	1
Post-Elution Rinse Volume (cv)	2.5
Post-Elution Rinse Rate (cv/hr)	1
Regeneration Volume (cv)	4.292
Regeneration Rate (cv/hr)	2.78
Regen Displacement Volume - Part 1 (gal)	1,050
Regen Displacement Rate - Part 1 (cv/hr)	0.94
Regen Displacement Volume - Part 2 (gal)	200
Regen Displacement Rate - Part 2 (cv/hr)	1.5

Vessel Tag #	Equipment Description
CXP-VSL-00005	Cesium Reagent Vessel

The Cesium Reagent Vessel is initially filled up with 0.1M NaOH from a chem-add source. The solution is used for ion exchange column displacement as described previously. The vessel is replenished to its maximum level when the displacement solution is used.

Vessel Tag #	Equipment Description
CXP-VSL-00026A	Treated LAW Collection Vessel
CXP-VSL-00026B	Treated LAW Collection Vessel
CXP-VSL-00026C	Treated LAW Collection Vessel

The Treated LAW Collection Vessels receive feed from the CXP column that is polishing. Once the set volume is reached, the vessel is sampled and held for the prescribed sample time. Solubility correlations are applied at 45 °C before the vessel can be discharged. The Treated LAW Collection Vessels transfer feed to TLP-SEP-00001 one at a time. Flowrate is set to 34 gpm for feed-only pumping or 30 gpm for dual pumping. Feed-only pumping is performed when recycles from TLP-VSL-00009A and TLP-VSL-00009B are not ready for discharging. Dual pumping is performed when both treated LAW feed and recycle are fed to the TLP evaporator. Details of the dual pumping logic are discussed in Sections 4.8.8 and 4.8.9.

Figures F-8 and F-11 provide graphical illustrations of the CXP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the CXP.

4.8.5 Cesium Nitric Acid Recovery Process (CNP) System

Vessel Tag #	Equipment Description
CNP-EVAP-00001	Cesium Evaporator Separator Vessel
CNP-DISTC-00001	Cesium Evaporator Nitric Acid Rectifier
CNP-VSL-00003	Cesium Concentrate Storage Vessel
CNP-VSL-00004	Cesium Evaporator Recovered Nitric Acid Vessel

The process steps for the operation of the CNP are presented below:

- 1) CNP-EVAP-00001 is charged with 2,128 gallons of 5M HNO₃ from a chem-add source.
- 2) Waste from the CXP column elution and post-elution rinse is routed to CNP-EVAP-00001.
- 3) The rectifier column is modeled based on a material balance typical for a simple distillation tower (i.e., the column performance is based on the nitric acid recovery efficiency and bottoms composition). The HNO₃ recovery efficiency is applied to the G2 model at 99.5 %. The split of water in CNP-DISTC-00001 is dependent upon the amount of [H⁺] and [NO₃⁻] in the column so that the resulting solution to CNP-VSL-00004 is 0.5M HNO₃. Distillate is recycled to PWD-VSL-00015 or PWD-VSL-00016 depending on their availability.
- 4) CNP-VSL-00004 provides the source of nitric acid for CXP column resin elution. The vessel receives recycle from the rectifier column and operates between the upper set volume at 7,342 gallons and the lower set volume at 5,342 gallons. The vessel is filled initially to the lower set volume with 0.45M HNO₃ from a chem-add source and is replenished when the volume reaches below the lower set volume.
- 5) Once the Z value in Eq. 51 reaches above the 80 % saturation limit, the evaporator makes itself available to empty (step 6), until then the evaporator continues to collect eluant and rinse solution (step 2).
- 6) The contents of the evaporator are discharged to CNP-VSL-00003, then to HLP-VSL-00028 or HLP-VSL-00027B in priority order depending on the following conditions: a) If HLP-VSL-00028 is in the beginning of a “fill” cycle, for example the volume is at or slightly above the 27,000-gallon heel, b) If HLP-VSL-00027B is in “fill” mode, and the volume of HLP-VSL-00027B is greater than 61,800 gallons, and the remaining volume of HLP-VSL-00027B can receive up to 2,615 gallons of CNP concentrate plus the associated caustic for neutralization. The maximum volume of CNP-VSL-00003 that can be discharged in one batch is 2,615 gallons, which limits the reaction heat generated from the neutralization. Before discharging, 19M NaOH will be added to the receiving HLW Lag Storage or Feed Blending Process System (HLP) vessel. The volume of caustic is determined based on an OH- to H+ ratio = 1.1 to 1, excluding the OH- already in the receiving HLP vessel. Refer to Section 4.8.12 for further details on acid neutralization.
- 7) The evaporator sets itself to recharge with acid (step 1).

Eluant is boiled off from CNP-EVAP-00001 and is routed to CNP-DISTC-00001 at the same rate that material enters CNP-EVAP-00001. The flowrate into and out of the evaporator will be the same, maintaining a constant level in the evaporator. Equations 46 through 49 are used to calculate the liquid-vapor equilibrium between the concentrate and overheads in CNP-EVAP-00001.

$$\begin{array}{ll} \text{Acid activity coefficient for HNO}_3\text{-H}_2\text{O system} & -\text{Log}_{10}(\gamma_{AW}) = \left(\frac{1}{A \left(\frac{x_c^a}{x_c^w} \right) + B} \right)^2 \end{array} \quad (\text{Eq. 46})$$

$$\begin{array}{ll} \text{Influence of solute on acid activity coefficient} & \frac{\gamma_a}{\gamma_{AW}} = 1 + 7.812 x_c^n \end{array} \quad (\text{Eq. 47})$$

$$\begin{array}{ll} \text{Vapor-Liquid Equilibrium between concentrate and overheads} & x_o^a = \frac{\gamma_a x_c^a P_A^{\text{sat}}}{P} \end{array} \quad (\text{Eq. 48})$$

$$\text{Saturation pressure (torr)} \quad P_A^{\text{sat}} = 2.9163 \times 10^8 e^{-4592.6/T} \quad (\text{Eq. 49})$$

Where:

γ_{AW}	=	Nitric acid activity coefficient in the binary HNO ₃ -H ₂ O system (dimensionless)
A	=	$4.029672 e^{-444.877899/T}$ (dimensionless)
B	=	$0.002114 \times T - 0.093403$ (dimensionless)
X_c^a	=	The mole fraction of acid in CNP-EVAP-00001 (the kg-moles of [H ⁺] divided by the sum of kg-moles of H ₂ O, [H ⁺], and [Na ⁺] + [Nap ⁺])
X_c^w	=	The mole fraction of water in CNP-EVAP-00001 (the kg-moles of H ₂ O divided by the sum of kg-moles of H ₂ O, [H ⁺], and [Na ⁺] + [Nap ⁺])
γ_a	=	Nitric acid activity coefficient relating acid composition of overhead to concentrate composition (dimensionless)
X_c^n	=	The mole fraction of sodium in CNP-EVAP-00001 (the kg-moles of [Na ⁺] + [Nap ⁺] divided by the sum of kg-moles of H ₂ O, [H ⁺], and [Na ⁺] + [Nap ⁺])
X_o^a	=	The mole fraction of acid in the offgas stream of CNP-EVAP-00001 (the kg-moles of [H ⁺] divided by the sum of kg-moles of H ₂ O and [H ⁺] in the offgas stream)
P	=	Total system pressure (70 torr)
T	=	Temperature (328.15 K)

Once the mole fraction of acid (X_o^a for [H⁺] and [NO₃⁻]) in the offgas is determined, the kg-moles of [H⁺], [NO₃⁻] and H₂O boil-off can be calculated. Equations 50 and 51 are used to determine the endpoint concentration equivalent to 80 % saturation limit.

$$S_{\text{sat}} = (0.00657[\text{Al}+3] + 0.01215[\text{Ca}+2] + 0.01655[\text{Cs}+] + 0.1046[\text{Fe}+3] + 0.00957[\text{K}+] + 0.00586([\text{Na}+] + [\text{Nap}+]) + 0.0058[\text{H}+] + 0.00454[\text{Others}]) \times 100 \quad (\text{g/mL}) \quad (\text{Eq. 50})$$

$$Z = (S - H^\circ) / (S_{\text{sat}} - H^\circ) \times 100 \quad (\text{percent}) \quad (\text{Eq. 51})$$

Where:

S_{sat}	=	saturation at 20 °C (g/mL)
S	=	saturation (g/mL)
Z	=	the approach to saturation (percent)
H°	=	initial concentration (g/mL)
[cation total]	=	the sum of all cations
[Al+3]	=	$([\text{Al}(\text{OH})4-] + [\text{Al}+3]) / [\text{cation total}]$
[Ca+2]	=	$[\text{Ca}+2] / [\text{cation total}]$
[Cs+]	=	$([134-\text{Cs}] + [137-\text{Cs}] + [\text{Cs}+]) / [\text{cation total}]$
[Fe+3]	=	$[\text{Fe}+3] / [\text{cation total}]$
[K+]	=	$[\text{K}+] / [\text{cation total}]$
[Na+]	=	$[\text{Na}+] / [\text{cation total}]$
[Nap+]	=	$[\text{Nap}+] / [\text{cation total}]$

$$\begin{aligned} [\text{H}^+] &= [\text{H}^+] / [\text{cation total}] \\ [\text{Others}] &= 1 - ([\text{Al}+3] + [\text{Ca}+2] + [\text{Cs}+] + [\text{Fe}+3] + [\text{K}+] + [\text{Na}+] + [\text{Nap}+] + [\text{H}^+]). \end{aligned}$$

A density correlation specific to solutions dominated by the ternary system of nitric acid, sodium nitrate, and water is required for application in the cesium eluate concentration system. Eq. 52 was derived from binary density data that have been correlated from the *BARD*. For application, H^+ is considered present as HNO_3 with molecular weight of 63 g/gmol, Na^+ and Nap^+ is considered present as NaNO_3 and NapNO_3 with molecular weight of 85 g/gmol.

$$\rho = \frac{a_0}{1 - \frac{1000 (a_1 x_a + a_2 x_n)}{(63 x_a + 85 x_n + 18 x_w)}} \quad (\text{Eq. 52})$$

Where:

$$\begin{aligned} \rho &= \text{Solution density at a specified temperature, g/cm}^3 \\ a_0 &= \text{Function of temperature obtained from binary data correlations, g/cm}^3 \\ a_1, a_2 &= \text{Functions of temperature obtained from binary data correlations, g-L/gmol-cm}^3 \\ x_a &= \text{Mole fraction of HNO}_3 \text{ in solution} \\ x_n &= \text{Mole fraction of NaNO}_3 \text{ and NapNO}_3 \text{ in solution} \\ x_w &= \text{Mole fraction of water in solution} \end{aligned}$$

Data correlations for the temperature functions are shown by Eq. 53. Note that these data correlations were performed based on temperatures in °C and not based on absolute temperatures. The temperature range of applicability is 20 °C to 100 °C for a_0 and a_1 , but data limitations restrict a_2 to a temperature range of 20 °C to 55 °C. Therefore, the overall correlation temperature range of applicability is considered limited to 20 °C to 55 °C.

$$\begin{aligned} a_0 &= 1.0138 - 4.8625 \times 10^{-4} T \quad \text{g/cm}^3 \\ a_1 &= 0.032152 - 4.392 \times 10^{-5} T \quad \text{g - L/gmol - cm}^3 \\ a_2 &= 0.052057 - 4.2857 \times 10^{-5} T \quad \text{g - L/gmol - cm}^3 \end{aligned} \quad (\text{Eq. 53})$$

Where:

$$T = \text{Solution temperature, } ^\circ\text{C}$$

Figure F-10 provides a graphical illustration of the CNP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files which that used to track the process streams and material flows into and out of the CNP.

4.8.6 Cesium Fresh Resin Addition Process (CRP) System

Vessel Tag #	Equipment Description
CRP-VSL-00001	Cesium Resin Addition Vessel

After the resin goes through 40 loading cycles in the CXP columns, spent resin needs to be flushed out and fresh resin needs to be brought in. Resin capacity is set to 4.63 kg-moles/column, equivalent to 600 gallons of 6.8 mmole/g dry H-form dry resin. The Cesium Resin Addition Vessel (CRP-VSL-00001) performs the following functions for cesium fresh resin preparation and addition.

- 1) Fill CRP-VSL-00001 with 1,140 gallons of DIW from FRESH-RESIN-WATER.
- 2) Transfer 4.63 kg-moles of solid H⁺ RF resin to CRP-VSL-00001 from RF-RESIN, increment the conditioned-resin counter by 600 gallons.
- 3) Hold resins in CRP-VSL-00001 for 1 hour.
- 4) Drain CRP-VSL-00001 liquid (1,140 gallons) to the first available RLD-VSL-00017A/B vessel.
- 5) Add 720 gallons of DIW to CRP-VSL-00001 from FRESH-RESIN-WATER.
- 6) Add 470 gallons of 2M caustic to CRP-VSL-00001 from FRESH-RESIN-CAUSTIC.
- 7) Hold resins in CRP-VSL-00001 for 1 hour for H-form resin conversion as follows:

- 8) Drain 470 gallons of liquid from CRP-VSL-00001 to the first available RLD-VSL-00017A/B vessel.
- 9) Add 400 gallons of 2M caustic to CRP-VSL-00001 from FRESH-RESIN-CAUSTIC.
- 10) Hold resins in CRP-VSL-00001 for 1 hour for further H-form resin conversion as follows:

- 11) Wait until 40 loading cycles have been reached in a cesium ion exchange column.
- 12) Pump solution to RDP-VSL-00002A through the ion exchange column and transfer the fresh resin to the ion exchange column where the resins are saturated with 4.63 kg-moles of Nap⁺.
- 13) Repeat steps 1) through 12).

Figure F-9 provides a graphical illustration of the CRP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files which are used to track the process streams and material flows into and out of the CRP.

4.8.7 Spent Resin Collection and Dewatering Process (RDP) System

Vessel Tag #	Equipment Description
RDP-VSL-00002A	Spent Resin Slurry Vessel
RDP-VSL-00002B	Spent Resin Slurry Vessel
RDP-VSL-00002C	Spent Resin Slurry Vessel

After the resin goes through 40 loading cycles in the IX columns, spent resin needs to be flushed out and fresh resin needs to be brought in. The spent resin slurry vessels perform the following functions:

- 1) Fill RDP-VSL-00002A with 7,500 gallons of 0.25M NaOH from a chem-add initially.
- 2) Pump 7500 gallons from RDP-VSL-00002A to Cs IX column.
- 3) Route 7,085 gallons of solution from IX column to RDP-VSL-00002B.
- 4) Transfer 415 gallons spent resin to RDP-VSL-00002B.
- 5) Sample RDP-VSL-00002B (48 hours).
- 6) Pump fresh resin preparation solution (approximately 1,146 gallons) to IX column from CRP-VSL-00001.
- 7) Flush CRP-VSL-00001 to IX column line with 100 gallons of demin water.
- 8) Route IX column solution (approximately 415 [spent resin] + 1,146 [fresh resin preparation solution] + 100 [DIW] gallons) from IX column to RDP-VSL-00002A.
- 9) Pump 5,495 gallons of solution from RDP-VSL-00002B to RDP-VSL-00002A.
- 10) Wait 6 hours.
- 11) Flush RDP-VSL-00002B to RDP-VSL-00002A line with 800 gallons of DIW.
- 12) If FEP-VSL-00017A/B is available, pump 2040 gallons of solution from RDP-VSL-00002B to FEP-VSL-00017A/B. If FEP-VSL-00017A/B is not available, pump the solution to RDP-VSL-00002C, wait until FEP-VSL-00017A/B is available, pump from RDP-VSL-00002C to FEP-VSL-00017A/B.

Figure F-9 provides a graphical illustration of the RDP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the RDP.

4.8.8 Treated LAW Evaporation Process (TLP) System

Vessel Tag #	Equipment Description
TLP-VSL-00009A	LAW SBS Condensate Receipt Vessel
TLP-VSL-00009B	LAW SBS Condensate Receipt Vessel

The two LAW SBS Condensate Receipt Vessels will alternate operating modes between “receive” and “discharge” (e.g., one is to be filled or being filled while the other is to be emptied or being emptied). One at a time, the LAW SBS Condensate Receipt Vessels fill to their set level, sample for the prescribed time, and perform the following reactions:

Reaction	Conversion (Fraction)
$\text{H}_2\text{CO}_3 (\text{l}) \rightarrow \text{CO}_3^{2-} (\text{l}) + 2 \text{H}^+ (\text{l})$	1.0
$\text{HCO}_3^- (\text{l}) \rightarrow \text{CO}_3^{2-} (\text{l}) + \text{H}^+ (\text{l})$	1.0
$\text{NH}_4^+ (\text{l}) \rightarrow \text{NH}_3 (\text{l}) + \text{H}^+ (\text{l})$	1.0
$\text{Hg}^{+2} (\text{l}) + 2\text{OH}^- (\text{l}) \rightarrow \text{Hg}^{+2} (\text{s}) + \text{O}^{2-} (\text{s}) + \text{H}_2\text{O}(\text{Bound}) (\text{s})$	1.0
$\text{H}^+ (\text{l}) + \text{OH}^- (\text{l}) \rightarrow \text{H}_2\text{O} (\text{l})$	1.0

The pH of the vessels is adjusted to 12.0 with 5M NaOH after the reactions and before they can be emptied. The pumping rate for the vessel is set to 10 gpm. Under steady state operating conditions, the discharging vessel becomes “empty” before the receiving vessel gets ready for emptying because of the required sampling delay. As soon as the discharging vessel becomes “empty”, it is made available to

receive. This creates a condition that SBS recycles can be received continuously and is the preferred operating condition.

However, steady state conditions rarely exist in the dynamic model due to various factors. There are good possibilities that the receiving vessel reaches the set volume and the discharging vessel is still not “empty”. Under such circumstance, the contingency volume of the receiving vessel will be utilized.

In the case that the contingency volume is used up in the receiving vessel and the discharging vessel is still not “empty” under abnormal operating conditions, the discharging vessel will be switched to receiving mode and the receiving vessel will be allowed to discharge.

Although not in the baseline flowsheet design, a supplemental LAW vessel (SUPPLEMENTAL-LAW-RECYCLE) is included in the TLP for the option of modeling the additional capacity needed to process the LAW SBS/WESP condensate recycle. Details of the supplemental LAW vessel are noted in Section 4.7.14.

Vessel Tag #	Equipment Description
TLP-SEP-00001	Treated LAW Evaporator

The Treated LAW Evaporator is modeled to receive feeds from TLP-VSL-00009A or TLP-VSL-00009B, and/or CXP-VSL-00026A, CXP-VSL-00026B, CXP-VSL-00026C, defined as “feed-only”, “recycle-only,” and “dual-pumping”. Feed-only is the operation when TLP-SEP-00001 receives only the treated LAW feed from CXP-VSL-00026A, CXP-VSL-00026B, or CXP-VSL-00026C. Recycle-only is the operation when TLP-SEP-00001 is fed with recycle from TLP-VSL-00009A or TLP-VSL-00009B. Dual-pumping is the operation when TLP-SEP-00001 receives both feed and recycle concurrently. Pump rates for the three operations are given below:

- 1) Feed-Only
 - TLP-VSL-00009A/B = 0 gpm
 - CXP-VSL-00026A/B/C = 34 gpm
- 2) Recycle-Only
 - TLP-VSL-00009A/B = 10 gpm
 - CXP-VSL-00026A/B/C = 0 gpm
- 3) Dual-Pumping
 - TLP-VSL-00009A/B = 10 gpm
 - CXP-VSL-00026A/B/C = 30 gpm

Dominant operations are feed-only and dual-pumping, while recycle-only can also happen at times when HLW Facility backs up the UFP processes which stops the treated LAW production.

The target for evaporator concentrate is SpG = 1.33 and/or a wt% solids = 3.4%, whichever comes first. Oxalate and phosphate tend to precipitate in the evaporator after boil-off. Solubility is applied continuously at the flash evaporation temperature (50 °C) which may slightly alter the SpG and/or wt% solids values of the TLP evaporator bottom product. The rate of the evaporator is limited by the boil-off rate of 30 gpm – 2 gpm for the evaporator recycle spray to give a modeled boil-off rate of 28 gpm. Evaporator concentrate pump capacity is 34 gpm. The offgas from TLP-SEP-00001 is routed through TLP-DMST-00001. The splits for the evaporator are shown in Table D-10.

To minimize foaming, AFA is added to the evaporator when it starts receiving a new batch from a feed tank. AFA will be replenished after that in 1-hour intervals to make up losses due to decomposition and discharge. Target concentrations for PPG and PDMS are discussed in Section 4.7.17.

Vessel Tag #	Equipment Description
TLP-DMST-00001	Treated LAW Evaporator Demister

The Treated LAW Evaporator Demister receives offgas from TLP-SEP-00001. The demister is also modeled as a condenser. The offgas is condensed based on splits as shown in Table D-11. The condensate is sent to TLP-VSL-00002. The offgas that was not condensed is sent to PVP-SCB-00002 in the Pretreatment Vessel Vent System.

Vessel Tag #	Equipment Description
TLP-VSL-00002	Treated LAW Evaporator Condensate Vessel

The Treated LAW Evaporator Condensate Vessel receives condensate from the demister, TLP-DMST-00001. Water, used to model condensate from the vacuum eductors, is also delivered from a chem-add to TLP-VSL-00002 at a rate of 0.96 gpm whenever TLP-SEP-00001 is operating. As soon as the vessel reaches its maximum volume, it empties to RLD-VSL-00006A. TLP-VSL-00002 is available to receive condensate unless it is at maximum volume and RLD-VSL-00006A cannot accept feed.

Figure F-11 provides a graphical illustration of the TLP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the TLP.

4.8.9 Treated LAW Concentrate Storage Process (TCP) System

Vessel Tag #	Equipment Description
TCP-VSL-00001	Treated LAW Concentrate Storage Vessel

The Treated LAW Concentrate Storage Vessel receives the bottoms from TLP-SEP-00001. The vessel fills to its set level (75,000 gallons) and then makes itself available to deliver feed to LCP-VSL-00001 and LCP-VSL-00002. The Treated LAW Concentrate Storage Vessel can still receive feed while it is transferring out to another vessel. If the volume of TCP-VSL-00001 is above 80,000 gallons, then TLP-SEP-00001 is set to only process SBS condensate from TLP-VSL-00009A and TLP-VSL-00009B until the volume drops below 80,000 gallons (recycle-only operation as discussed in Section 4.8.8).

A supplemental LAW vessel (SUPPLEMENTAL-LAW-TREATED) is included in the TCP system for the option of modeling the additional capacity needed to process the treated LAW feed. Details of the supplemental LAW vessel operating logic are discussed in Section 4.7.14.

Figure F-11 provides a graphical illustration of the TCP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the TCP.

4.8.10 Pretreatment Vessel Vent Process (PVP/PJV) Systems

Vessel Tag #	Equipment Description
PVP-SCB-00002	Vessel Vent Caustic Scrubber

The Vessel Vent Caustic Scrubber receives offgas from FEP-DMST-00001 and TLP-DMST-00001. Air from air purge and air bubbler are blended into the offgas to the Vessel Vent Caustic Scrubber. The scrubber fills to its set volume with 0.01M NaOH that is delivered through a chem-add at a rate of 70 gpm. As the offgas is received in the scrubber, components are collected in the 0.01M NaOH solution based on splits. The splits of the Vessel Vent Caustic Scrubber are shown in Table D-3. The remaining gas is routed to PVP-SCB-00002. After 24 hours, the scrubber empties its contents at a rate of 50 gpm to PWD-VSL-00044. After emptying, it receives another batch of 0.01M NaOH and continues to remove components.

Vessel Tag #	Equipment Description
PVP-HEME-00001A	PVP High Efficiency Mist Eliminator (HEME)
PVP-HEME-00001B	PVP HEME
PVP-HEME-00001C	PVP HEME

PVP-HEME-00001 is used to model the combined functions of PVP-HEME-00001A, PVP-HEME-00001B, and PVP-HEME-00001C (see BARD for details). PVP-HEME-00001 receives offgas from PVP-SCB-00002. H₂O is constantly fed to PVP-HEME-00001 by a chem-add at a rate of 0.133 gpm. Components from the offgas feed are captured in the liquid phase based on splits. The splits of the PVP HEME are shown in Table D-4. The remaining gas is passed on to the PVP-HEPA. The liquid from PVP-HEME-00001 is transferred to PVP-VSL-00001.

Vessel Tag #	Equipment Description
PVP-VSL-00001	Vessel Vent HEME Drain Collection Vessel

PVP-VSL-00001 constantly receives liquid from PVP-HEME-00001. This collection vessel fills to its set level and then transfers its contents to PWD-VSL-00044. If PWD-VSL-00044 is not available to receive material, then PVP-VSL-00001 can continue to fill to its maximum volume until PWD-VSL-00044 becomes available. If PVP-VSL-00001 reaches its maximum volume and still cannot empty, then the Pretreatment Vessel Vent Process will shut down.

Vessel Tag #	Equipment Description
PVP-HEPA	High Efficiency Particular Air (HEPA) Filter

The PVP-HEPA receives offgas from PVP-HEME-00001. Liquid and solid components from the offgas feed are captured at the 100 % level except for polychlorinated biphenyls (PCBs) (C₁₂H₄Cl₆), which is captured at the 98 % level, and acetonitrile (C₂H₃N), which escapes totally to the downstream equipment. The gas is routed to the PVP-Thermal-Oxidizer.

Vessel Tag #	Equipment Description
PVP-Thermal-Oxidizer	PVP Thermal Oxidizer

The PVP Thermal Oxidizer receives offgas from PVP High Efficiency Particular Air Filter. Acetonitrile and PCB are oxidized according to the following reactions. The gases are routed to the PVP-Carbon-Absorber.

Reaction	Conversion (Fraction)
C ₂ H ₃ N (l) + 3.75 O ₂ (g) → 2 CO ₂ (g) + 1.5 H ₂ O (g) + NO ₂ (g)	0.757
C ₁₂ H ₄ Cl ₆ (l) + 11.5 O ₂ (g) + H ₂ O (g) → 12 CO ₂ (g) + 6 HCl (g)	0.95

Vessel Tag #	Equipment Description
PVP-ABS-00001A	PVP Carbon Absorber
PVP-ABS-00001B	PVP Carbon Absorber

PVP-ABS-00001A and PVP-ABS-00001B are modeled as one unit operation, the PVP Carbon Absorber. The PVP Carbon Absorber receives offgas from PVP Thermal Oxidizer. Acetonitrile and PCB gases are also captured at the 90 % level. Remaining gases are routed to the PVP Offgas Stack.

Vessel Tag #	Equipment Description
PJV-VSL-00001	PJV Vessel Vent Demister

PJV-VSL-00001 in the Pulse Jet Ventilation (PJV) system is used to model PJV-DMST-00002A, PJV-DMST-00002B, and PJV-DMST-00002C. PJV-VSL-00001 receives gas from multiple sources of air as part of the Pulse Jet Mixer (PJM) and Reverse Flow Diverter (RFD). Components from the gas feed are captured by the demister based on splits. The splits of the PJV Vessel Vent Demister are shown in Table D-8. Cumulated captures are sent to PWD-VSL-00043 and the remaining gases are routed to the PJV HEPA.

Vessel Tag #	Equipment Description
PJV-HEPA	PJV HEPA Filter

The PJV HEPA receives offgas from PJV-VSL-00001. Liquid and solid components from the offgas feed are captured at the 100 % level. The splits of the PJV HEPA Filter are shown in Table D-9. The gas is passed out the PVP-Offgas-Stack.

Figure F-6 provides a graphical illustration of the PVP/PJV systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the PVP/PJV.

Dynamic air utilization modeling capabilities including the purge air, bubbler air, PJM air, and RFD air are discussed in Appendix G.

4.8.11 Radioactive Liquid Waste Disposal (RLD) System

Vessel Tag #	Equipment Description
RLD-VSL-00017A	Alkaline Effluent Vessel
RLD-VSL-00017B	Alkaline Effluent Vessel

The Alkaline Effluent Vessels receive fresh resin preparation solution from the Cesium Resin Addition Vessel (CRP-VSL-00001) and effluent from the Caustic Collection Vessel (LVP-TK-00001). When RLD-VSL-00017A/B reaches its set level, it will stop receiving feed, sample for a prescribed time, and then make itself available to empty to RLD-TK-00006B. The vessels are not allowed to collect at the same time. One of the vessels must fill and begin to sample before the other is allowed to start receiving feed.

Vessel Tag #	Equipment Description
RLD-TK-00006A	Process Condensate Vessel

RLD-TK-00006A receives feed from the Waste Feed Evaporator Condensate Vessel (FEP-VSL-00005) and the Treated LAW Evaporator Condensate Vessel (TLP-VSL-00002). A portion of the process

condensate will be recycled to various Pretreatment systems for washing, dilution, and line flush operations. Excessive process condensate will be sent to the ETF/LERF through RLD-TK-00006B.

When RLD-TK-00006A reaches above 200,000 gallons (upper set point), the vessel volume will be pumped down to 110,000 gallons (lower set point) by discharging to RLD-TK-00006B. The inventory between the heel and lower set point is reserved for the Pretreatment process condensate operations. It is possible for concurrent transfers from RLD-TK-00006A to RLD-TK-00006B and to the process condensate header because they are on separate pumping systems. The pump rate to RLD-TK-00006B is 100 gpm and the pump rate to the process condensate header is 250 gpm.

Vessel Tag #	Equipment Description
RLD-TK-00006B	Process Condensate Vessel

RLD-TK-00006B receives feed from the following vessels:

Vessel Tag #	Equipment Description
RLD-VSL-00017A	Alkaline Effluent Vessel
RLD-VSL-00017B	Alkaline Effluent Vessel
RLD-TK-00006A	Process Condensate Vessel

When RLD-TK-00006B reaches its set level, the vessel will empty its contents to the ETF/LERF which is modeled as an infinite vessel collecting all the effluent transfers. The pump rate to ETF/LERF is 170 gpm.

Vessel Tag #	Equipment Description
RLD-VSL-00004	C3/C5 Drains/Sump Collection Vessel

RLD-VSL-00004 receives liquid continuously from the LAW WESP columns. When the level reaches the setpoint, the vessel empties its contents into RLD-VSL-00005.

Vessel Tag #	Equipment Description
RLD-VSL-00005	SBS Condensate Collection Vessel

RLD-VSL-00005 receives material from RLD-VSL-00004 and LAW-SBS. When the setpoint level of RLD-VSL-00005 has been reached, the vessel empties to either TLP-VSL-00009A or TLP-VSL-00009B depending on their availability.

Vessel Tag #	Equipment Description
RLD-VSL-00007	Acidic Waste Vessel

The Acidic Waste Vessel receives material from the HLW SBS Condensate Vessels (HOP-SCB-00001, HOP-SCB-00002) and the Waste Neutralization Vessel (HDH-VSL-00003) one at a time. A transfer can be made if RDL-VSL-00007 is not currently discharging and the volume is below the 8,662-gallon setpoint. If two or three of the upstream vessels need to be discharged at the same time (rarely occurs), the upstream vessel that reaches the upper setpoint first gets the priority to discharge, and the upstream vessel(s) with lower priority will continue to receive. RLD-VSL-00007 receives until the setpoint level is reached. Transfer lines are flushed with process water at the end of each batch and flush volumes can be found in Table H-1. If necessary 5M NaOH is added to bring the pH up to 8.0. After pH adjustment the vessel empties its contents into PWD-VSL-00043.

If RLD-VSL-00007 is unable to discharge due to PWD-VSL-00043 vessel's unavailability to receive, the HLW melter feed pumps will be shut down temporary. This provides relief to RLD-VSL-00007 from the HLW SBS Condensate Vessels and the Waste Neutralization Vessel.

Figures F-16, F-22, F-24, and F-25 provide graphical illustrations of the RLD/Condensate and RLD/Effluent systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the RLD/Condensate and RLD/Effluent.

4.8.12 HLW Lag Storage and Feed Blending Process System

Vessel Tag #	Equipment Description
HLP-VSL-00022	HLW Feed Receipt Vessel

The HLW Feed Receipt Vessel receives batch transfers of HLW feed and associated pre-transfer and post-transfer line flushes of inhibited water from the Tank Farms. The vessel also receives line flush water from various operations shown in Table H-1. In general, the transfer lines are flushed after each use. Due to piping configurations, the destination of the flush water is not only to the pumping and receiving vessels, but may also include other FRP and FEP vessels. Headspace, as defined as the storage between the set volume and the maximum volume, is reserved in HLP-VSL-00022 for the line flush water. The vessel is constrained to not fill above its maximum volume.

Once a year, a heel dilution is performed in HLP-VSL-00022 to reduce solids concentration in the heel that may have accumulated. Fluids used for dilution are LAW feeds from FRP-VSL-00002A/B/C/D, process condensate, or DI water in preferred orders. The HLP-VSL-00022 heel dilution is scheduled to separate with other heel dilution operations in FEP-VSL-00017A/B and UFP-VSL-00001A/B. The portable pump connects HLP-VSL-00022 with UFP-VSL-00001B and will only discharge when UFP-VSL-00001B is in a receiving mode. Refer to Section 4.7.20 for further details on general rules of heel dilution and HLP-VSL-00022 specific volume parameters.

Batches are not mixed in the vessel except for the waste in the heel from the previous batch. The vessel is filled to its set volume or until the full batch has been received. Solubility correlations are applied at 25 °C. A sample is taken and the vessel is held for the prescribed sample time. The vessel transfers waste feeds to either UFP-VSL-00001A or UFP-VSL-00001B, depending on their availability, according to the feed blending logic described in Section 4.8.3.

Vessel Tag #	Equipment Description
HLP-VSL-00027A	HLW Lag Storage Vessel
HLP-VSL-00027B	HLW Lag Storage Vessel
HLP-VSL-00028	HLW Feed Blending Vessel

The HLW Lag Storage Vessels and Feed Blending Vessel can receive feeds from the following vessels:

Vessel Tag #	Equipment Description
FEP-SEP-00001A/B	Waste Feed Evaporator
UFP-VSL-00002A/B	Ultrafiltration Feed Vessel
RLD-TK-00006A	Process Condensate Vessel
CNP-EVAP-00001	Cesium Evaporator Separator Vessel
CXP-VSL-00001	Eluate Contingency Storage Vessel

When the backend leaching operations are chosen, both the HLP-VSL-00027A and HLP-VSL-00027B vessels are used to receive solids from UFP2. A HLP-VSL-00027 vessel can receive multiple batches of solids until the last batch raises the volume to above the upper set point. The vessel also receives 150 gallons of inhibited water at 90 gpm from line flush at the end of each batch transfer. The two vessels work in an alternating fashion.

HLP-VSL-00028 receives feeds from HLP-VSL-00027A/B and associated line flush water as shown in Table H-1. HLP-VSL-00028 and HLP-VSL-00027B can also receive CNP evaporator concentrate from CNP-VSL-00003 in priority order based on the following conditions. A maximum of 2,615 gallons can be received in one batch.

- If HLP-VSL-00028 is in the beginning of a “fill” cycle, for example, volume is at or slightly greater than 27,000 gallons
- Else if HLP-VSL-00027B is in “fill” mode, and the volume of HLP-VSL-00027B is greater than 61,800 gallons, and the remaining volume of HLP-VSL-00027B can receive up to 2,615 gallons of CNP concentrate plus the associated caustic for neutralization
- Else wait until the above condition(s) become true

Before CNP evaporator concentrate can be transferred into either HLP-VSL-00028 or HLP-VSL-00027B, caustic (19M NaOH) is added to the receiving vessel. The volume of caustic is determined by calculating the amount of caustic necessary to achieve an OH^- to H^+ ratio of 1.1 to 1, excluding the OH^- already in the receiving vessel. There is a 30-minute wait after the CNP material is received to allow mixing and neutralization reaction to take place.

HLP-VSL-00028 will be topped off with wastes from HLP-VSL-00027A/B after neutralization. The minimum cool down time after neutralization and before discharging is 40 hours. HLP-VSL-00027B can be discharged after neutralization and cooling. The minimum cool down time after neutralization is 100 hours.

HLP-VSL-00028 is sampled, held for the prescribed time, then discharged. HLP-VSL-00028 discharges to the HLW MFPV in batches. Batch size is determined based on waste composition, glass formulation, glass former dusting water, water from line flush and rheology operations. All these operating variables are inter-related as:

glass formulation = function (waste composition)

glass former dusting water = function (glass formulation)

rheology = function (waste composition, glass formulation, line flush, glass former dusting water)

The goal is to fill the HLW MFPV to the maximum volume after all of the above have been transferred in. An iterative approach is taken to solve for the batch size for waste (see Section 4.8.17 for further discussions). If the remaining volume of HLP-VSL-00028 is less than the calculated batch size, the HLP-VSL-00028 vessel is switched from discharge to receive. Transfer lines are back flushed after each use with significant volumes of process condensate or water being placed in the HLP-VSL-00028 and PWD-VSL-00043 vessels (Table H-1).

To minimize foaming, AFA is added to HLP-VSL-00027A, HLP-VSL-00027B, and HLP-VSL-00028 when the vessels have been filled to above the set volume. AFA will be replenished after that in 6-hour intervals to account for losses due to decomposition and discharge. Target concentrations for PPG and PDMS are discussed in Section 4.7.17.

Twice a year, heel cleanout are performed in HLP-VSL-00027A/B and HLP-VSL-00028 to reduce solids concentration in the heel that may have accumulated. Fluids used for cleanout are concentrated solids from UFP-VSL-00002A/B for the HLP-VSL-00027A/B vessels and concentrated solids from HLP-VSL-00027A/B for the HLP-VSL-00028 vessel. The HLP-VSL-00027A/B and HLP-VSL-00028 heel cleanout are scheduled to offset one with another. The portable pump connects HLP-VSL-00027A/B with HLP-VSL-00028 and connects HLP-VSL-00028 with HFP-VSL-00001/5. Refer to Section 4.7.20 for further details on general rules of heel cleanout and HLP-VSL-00027A/B and HLP-VSL-00028 specific volume parameters.

Figure F-17 provides a graphical illustration of the HLP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the HLP.

4.8.13 LAW Concentrate Receipt Process (LCP) System

Vessel Tag #	Equipment Description
LCP-VSL-00001	LAW Concentrate Receipt Vessel
LCP-VSL-00002	LAW Concentrate Receipt Vessel

The LAW Concentrate Receipt Vessels (CRV) receive material from TCP-VSL-00001 and alternate with each other in operation. When a LAW CRV has reached its maximum level, the vessel samples for a prescribed time, then becomes available to empty to either LFP-VSL-00001 or LFP-VSL-00003 depending on their availability. Based on the CRV sample compositions, batch size and glass former recipes will be determined. Batch size determines the number of transfers that can be made to the LAW MFPVs. Glass former recipes are determined using the Immobilized Low-Activity Waste (ILAW) glass formulation model shown in Figures 12 through 14 (refer to the *BARD* for further details). The batch size and glass former recipe decisions ensure that

- 1) LFP-VSL-00001 or LFP-VSL-00003 will not overflow
- 2) Rheology water target is met (36 wt % water)
- 3) LAW glass quality specifications are met
- 4) Melter corrosion due to high lithium contents in the feed is prevented
- 5) Halide, chromium, and phosphate will not hinder melting process

The number of requests for LAW glass former recipes are equal to the number of batches to the LAW MFPVs. Glass formers can be prepared as soon as recipes exist in the LAW recipe queue given that the GFR is available. It shall be noted that GFR priorities are given to HLW glass formers, e.g., HLW recipes will be processed first if requests exist in both LAW recipe queue and HLW recipe queue (refer to Section 4.8.22 for GFR operations). Due to the fact that LAW glass former recipes are known for future LAW CRV to LAW MFPV batches, LAW glass formers can be prepared in parallel to, or even ahead of, the CRV to MFPV waste transfers.

Transfer lines are flushed with process water after each use and both the CRV and MFPV will receive some flush water (Table H-1). Partial batch transfer to the MFPV is prohibited, meaning that the CRV will switch to filling mode if the remaining volume in the vessel is less than a full batch. After the pre-determined number of batches have been transferred out, the CRV makes itself available to fill.

Figure 12 ILAW Glass Formulation Model (Part 1)

Figure 13 ILAW Glass Formulation Model (Part 2)

Figure 14 ILAW Glass Formulation Model (Part 3)

The glass former recipe, including the quantities of borax, boric acid, kyanite, lithium carbonate, olivine, rutile, soda ash, sugar, wollastonite, zinc oxide, and zircon sand, are returned from the ILAW glass formulation model.

4.8.14 LAW Feed Preparation Process (LFP) System

Vessel Tag #	Equipment Description
LFP-VSL-00001	LAW Melter 1 Feed Prep Vessel
LFP-VSL-00003	LAW Melter 2 Feed Prep Vessel

LFP-VSL-00001 receives waste feed from LCP-VSL-00001 or LCP-VSL-00002, and glass former from GFR-TK-00023. LFP-VSL-00003 receives waste feed from LCP-VSL-00001 or LCP-VSL-00002, and glass former from GFR-TK-00022. The LAW MFPV set volume is batch dependent and is associated with the current LAW glass former recipe, dusting water quantity, and rheology water. The goal is to fill the MFPV to a prescribed volume after the waste, glass formers, dusting water, and rheology water are received. Figure 15 shows the iterative approach for determining the MFPV set volume. The vessel is held 0.75 hours for a confirmation sampling before becomes available for discharge. A specified volume of flush water is placed in the MFPV after sampling (Table H-1). LFP-VSL-00001 empties its contents to

LFP-VSL-00002 and LFP-VSL-00003 empties its contents to LFP-VSL-00004. Transfer lines are flushed with process water after each use and both the MFPV and MFV receive additional volumes of flush water. After emptying, the LAW MFPV starts a new cycle.

Figure 15 MFPV Batch Size Determination Logic

Vessel Tag #	Equipment Description
LFP-VSL-00002	LAW Melter 1 Feed Vessel
LFP-VSL-00004	LAW Melter 2 Feed Vessel

The LAW MFVs receive feed from the corresponding LAW MFPVs. LFP-VSL-00002 transfers material only to LMP-MLTR-00001 and LFP-VSL-00004 transfers material only to LMP-MLTR-00002. Transfer rate is variable depending on the contents of the waste. A more diluted feed will have a higher transfer rate so that the target melter production rate can be maintained. When a LAW MFV reaches its lower setpoint (1,000 gallons) it becomes available to receive feed again while continuing to empty to its minimum volume (977 gallons). This prevents the LAW melter from becoming idle. The only time that an LAW MFV will stop pumping to the melter is when there is no feed available from the LAW MFPV and the LAW MFV is at its minimum volume.

After the MFV receives a batch transfer from the MFPV and after the MFV completes a batch discharge, process water are flushed into the MFV and associated melter (Table H-1). Process water is also flushed into the receiving melter once every 4 hours between the cycle.

Figure F-12 provides a graphical illustration of the LCP/LFP systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the LCP/LFP.

4.8.15 LAW Melter Process (LMP) System

Vessel Tag #	Equipment Description
LMP-MLTR-00001	LAW Melter 1
LMP-MLTR-00002	LAW Melter 2

LAW Melters (LMP-MLTR-00001 and LMP-MLTR-00002) are used to transform the LAW into glass. Liquid and solid wastes, oxide glass formers and impurities, lineflush water, air, and film cooler water rinse are delivered to the melters. The inflow of waste and glass formers depends on the availability of feed; however, the inflow of air is continuous once started. The air stream is made up of: 1) air inleakage, 2) bubbler air, 3) purge air, 4) control air, and 5) cooling air, while the water stream represents the film cooler water rinse. The combined air flowrate and the associated temperature and pressure are shown in Table B-15. The film cooler water rinse flowrate is shown in the same table. The air provides the source of oxygen for the melter reactions.

When feed enters the melter, a split is applied to the non-gas components including the liquid and solid wastes, and oxide glass formers and associated mineral impurities. The liquid split values apply to the liquid components that come into the melter while the solid split values apply to the combined solids of solid wastes, oxide glass formers, and impurities. The predefined split values are shown in Table D-12. Exceptions are applied to the following components of which melter reactions or a combination of melter reactions and splits are more appropriate:

Components	Liquid% to SBS	Solid% to SBS	Descriptions
129-I	0.000	0.000	129-I (l,s) → 129-I (g) CF = 0.4167, remaining go to glass
3-H	100.000	100.000	Follows water, 100% go to offgas
C12H4Cl6	0.000	0.000	C12H4Cl6 (l,s) + 11.5 O2 (g) + H2O (l) → 12 CO2 (g) + 6 HCl (g) CF = 1.0
C2H3N	0.000	0.000	C2H3N (l,s) + 3.75 O2 (g) → 2 CO2 (g) + 1.5 H2O (g) + NO2 (g) CF =

Components	Liquid% to SBS	Solid% to SBS	Descriptions
			1.0
C2O4-2	0.000	0.000	C2O4-2 (l,s) → 2 CO2 (g) CF = 1.0
CHO2-	0.000	0.000	CHO2- (l,s) + 0.25 O2 (g) → CO2 (g) + 0.5 H2O (g) CF = 1.0
Cl-	0.000	0.000	2 Cl- (l,s) + 2 Na+ (l,s) + H2O (l) → Na2O (o) + 2 HCl (g) CF = 0.5025, remaining go to glass
CN-	1.754	1.754	2 CN- (l,s) + 2 O2 (g) → 2 CO2 (g) + N2 (g), CF = 1.0, partially split to offgas, remaining 100% destroyed
CO3-2	0.000	0.000	CO3-2 (l,s) → CO2 (g) + 0.5 O2 (g) CF = 1.0
F-	0.000	0.000	2 F- (l,s) + 2 Na+ (l,s) + H2O (l) → Na2O (o) + 2 HF (g) CF = 0.5319, remaining go to glass
H+	0.000	0.000	H+ (l,s) + OH(BOUND) (l,s) → H2O (g) CF = 1.0
H2CO3	0.000	0.000	H2CO3 (l,s) → CO2 (g) + H2O (g) CF = 1.0
H2O	0.000	0.000	H2O (l,s) → H2O (g) CF = 1.0
H2O2	0.000	0.000	2 H2O2 (l,s) → 2 H2O (g) + O2 (g) CF = 1.0
HCO3-	0.000	0.000	2 HCO3- (l,s) → 2 CO2 (g) + H2O (g) + 0.5 O2 (g) CF = 1.0
NH3	0.000	0.000	2 NH3 (l,s) + 3 O2 (g) → NO (g) + NO2 (g) + 3 H2O (g) CF = 1.0
NH4+	0.000	0.000	2 NH4+ (l,s) + 3.5 O2 (g) → NO (g) + NO2 (g) + 4 H2O (g) CF = 1.0
NO2-	0.000	0.000	See Eq. 55 in the following discussions
NO3-	0.000	0.000	See Eq. 54 in the following discussions
O-2	0.000	0.000	2 O-2 (l,s) → O2 (g) CF = 1.0
OH(BOUND)	0.000	0.000	2 OH(Bound) (l,s) → H2O (g) + 0.5 O2 (g) CF = 1.0
OH-	0.000	0.000	2 OH- (l,s) → H2O (g) + 0.5 O2 (g) CF = 1.0
SO4-2	0.000	0.000	SO4-2 (l,s) → SO2 (g) + O2 (g), CF is dynamically determined, remaining is oxidized and go to glass
TOC	0.000	0.000	TOC (l,s) + O2 (g) → CO2 (g) CF = 1.0

Nitrate and nitrite decomposition reactions are shown as Eq. 54 and Eq. 55 where the stoichiometric coefficients are dependent upon the variable multiplier M. These reactions provide the means for approximating the test data which found the SBS solution to be near neutral (pH = 6.5 to 7.5) due to variations of ammonia gas production rate.

where the stoichiometric coefficients are given as follows:

r11: 1	r21: 1
r12: 0.03623×M	r22: 0.03623×M
p11: 0.2546-0.0121×(M-1)	p21: 0.2546-0.0121×(M-1)
p12: 0.4239	p22: 0.4239
p13: 0.04277	p23: 0.04277
p14: 0.024154×M	p24: 0.024154×M
p15: 1.01339+0.0181×(M-1)	p25: 0.5134+0.0181×(M-1)

M is a multiplier that can be used to determine the ammonia production rate in the next time step. As the pH values of the SBSs are very sensitive to the ammonia gas production in the melters, variable M values are applied based on the current pH value in the SBS. A lookup table is provided as follows:

Current pH	M
pH <= 3.0	1.05
3.0 < pH <= 4.0	1.01
4.0 < pH <= 5.0	1.005
5.0 < pH <= 6.0	1.001
6.0 < pH <= 6.5	1.0001
6.5 < pH <= 7.0	1.00001
7.0 < pH <= 7.5	0.99999
7.5 < pH <= 8.0	0.9999
8.0 < pH <= 9.0	0.999
9.0 < pH <= 10.0	0.995
10.0 < pH <= 11.0	0.99
11.0 < pH	0.95

Ammonia production rate increases as M value increases. Relationships of NH₃ production in the melter and pH in the SBS are discussed in Section 4.8.16.

The conversion factor for the SO₄-2 decomposition reaction is also determined dynamically depending on the concentration of SO₄-2 in the feed:

$$C_{SO_3} = 0.22369 / (M_{Na_2O} / (M_{SO_3} + 20.321)) \quad \text{Eq. (56)}$$

If $C_{SO_3} \leq 0.002941$ or $C_{SO_3} \geq 0.008$ then

$$DF_{SO_4} = 8000 \quad \text{Eq. (57)}$$

Else

$$DF_{SO_4} = 1 / (73.5 \times C_{SO_3} - 0.216) \quad \text{Eq. (58)}$$

$$CF_{SO_4} = 1 / DF_{SO_4} \quad \text{Eq. (59)}$$

Where:

C_{SO_3} = SO₃ if 100% of the SO₄-2 are converted to glass (unitless)
 M_{Na_2O} = Na₂O equivalent of the melter feed sodium (kgs)
 M_{SO_3} = SO₃ equivalent of the melter feed sulfate (kgs)
 DF_{SO_4} = LAW melter decontamination factor for sulfate (unitless)
 CF_{SO_4} = Conversion factor for the SO₄-2 (l,s) decomposition reaction (fraction)

After splitting to the offgas system, the remaining solid and liquid arrays are combined in the liquid array and the following reactions occur in each melter, reactions take place in the order presented (note that some reactions have been shown in the table above).

Organic Destruction Reactions	Conversion (Fraction)
14-C (l,s) + O ₂ (g) → CO ₂ (g)	0.0 (14-C is 100% split)
TOC (l,s) + O ₂ (g) → CO ₂ (g)	1.0

Organic Destruction Reactions	Conversion (Fraction)
$C_{12}H_4Cl_6(l,s) + 11.5 O_2(g) + H_2O(l) \rightarrow 12 CO_2(g) + 6 HCl(g)$	1.0
$C_2H_3N(l,s) + 3.75 O_2(g) \rightarrow 2 CO_2(g) + 1.5 H_2O(g) + NO_2(g)$	1.0
$C_2O_4-2(l,s) \rightarrow 2 CO_2(g)$	1.0
$CHO_2-(l,s) + 0.25 O_2(g) \rightarrow CO_2(g) + 0.5 H_2O(g)$	1.0
$PPG(l,s) + 240 O_2(g) \rightarrow 180 CO_2(g) + 181 H_2O(g)$	1.0
$DPPG(l,s) + 240 O_2(g) \rightarrow 180 CO_2(g) + 181 H_2O(g)$	1.0
$PDMS(l,s) + 1892 O_2(g) \rightarrow 946 CO_2(g) + 1419 H_2O(g) + 472 SiO_2(o)$	1.0
$DPDMS(l,s) + 1892 O_2(g) \rightarrow 946 CO_2(g) + 1419 H_2O(g) + 472 SiO_2(o)$	1.0

Miscellaneous Reactions	Conversion (Fraction)
$2 Cl-(l,s) + 2 Na+(l,s) + H_2O(l) \rightarrow Na_2O(o) + 2 HCl(g)$	0.5025
$2 F-(l,s) + 2 Na+(l,s) + H_2O(l) \rightarrow Na_2O(o) + 2 HF(g)$	0.5319
$129-I(l,s) \rightarrow 129-I(g)$	0.4167
$Hg+2(l,s) \rightarrow Hg(g)$	1.0
$r_{11} \times NO_3^-(l,s) + r_{12} \times H_2O(l) \rightarrow p_{11} \times N_2(g) + p_{12} \times NO(g) + p_{13} \times NO_2(g) + p_{14} \times NH_3(g) + (0.25 + p_{15}) \times O_2(g)$	dynamically calculated
$r_{21} \times NO_2^-(l,s) + r_{22} \times H_2O(l) \rightarrow p_{21} \times N_2(g) + p_{22} \times NO(g) + p_{23} \times NO_2(g) + p_{24} \times NH_3(g) + (0.25 + p_{25}) \times O_2(g)$	dynamically calculated
$SO_4-2(l,s) \rightarrow SO_2(g) + O_2(g)$	dynamically calculated, remaining oxidized
$C_{12}H_{22}O_{11}(o) + 8 NO_3-(l,s) \rightarrow 6 C_2H_3N(g) + 2 H_2O(g) + N_2(g) + 16.5 O_2(g)$	0.0159
$C_{12}H_{22}O_{11}(o) + 6 HCl(g) + 0.5 O_2(g) \rightarrow C_{12}H_4Cl_6(g) + 12 H_2O(g)$	3.79e-10
$C_{12}H_{22}O_{11}(o) + 8 NO_3-(l,s) \rightarrow 12 CO_2(g) + 11 H_2O(g) + 4 N_2(g)$	0.6
$C_{12}H_{22}O_{11}(o) + 8 NO_2(l,s) + 4 O_2(g) \rightarrow 12 CO_2(g) + 11 H_2O(g) + 4 N_2(g)$	1.0
$C_{12}H_{22}O_{11}(o) + 12 O_2(g) \rightarrow 12 CO_2(g) + 11 H_2O(g)$	1.0
$2 CN-(l,s) + 2 O_2(g) \rightarrow 2 CO_2(g) + N_2(g)$	1.0
$CO_3-2(l,s) \rightarrow CO_2(g) + 0.5 O_2(g)$	1.0
$H+(l,s) + OH(BOUND)(l,s) \rightarrow H_2O(g)$	1.0
$H_2O(l,s) \rightarrow H_2O(g)$	1.0
$2 H_2O_2(l,s) \rightarrow 2 H_2O(g) + O_2(g)$	1.0
$2 HCO_3-(l,s) \rightarrow 2 CO_2(g) + H_2O(g) + 0.5 O_2(g)$	1.0
$H_2CO_3(l,s) \rightarrow CO_2(g) + H_2O(g)$	1.0
$2 NH_3(l,s) + 3 O_2(g) \rightarrow NO(g) + NO_2(g) + 3 H_2O(g)$	1.0
$2 NH_4+(l,s) + 3.5 O_2(g) \rightarrow NO(g) + NO_2(g) + 4 H_2O(g)$	1.0
$2 O-2(l,s) \rightarrow O_2(g)$	1.0
<ul style="list-style-type: none"> Sum OH- and OH(BOUND) to OH- (i.e., combine both components into OH-) 	
$2 OH-(l,s) \rightarrow H_2O(g) + 0.5 O_2(g)$	1.0

Oxidation Reactions	Conversion (Fraction)
$2 \text{ 227-Ac}(l,s) + 1.5 O_2(g) \rightarrow \text{Ac}_2O_3(o)$	1.0
$2 \text{ Ag}+(l,s) + 0.5 O_2(g) \rightarrow \text{Ag}_2O(o)$	1.0
$2 \text{ Al}+3(l,s) + 1.5 O_2(g) \rightarrow \text{Al}_2O_3(o)$	1.0
$2 \text{ Al}(\text{OH})_4-(l,s) \rightarrow \text{Al}_2O_3(o) + 0.5 O_2(g) + 4 H_2O(g)$	1.0
$2 \text{ Al}(\text{OH})_3(l,s) \rightarrow \text{Al}_2O_3(o) + 3 H_2O(g)$	1.0
<ul style="list-style-type: none"> Sum 241-Am and 243-Am to 241-Am 	
$2 \text{ 241-Am}(l,s) + 1.5 O_2(g) \rightarrow \text{Am}_2O_3(o)$	1.0
$2 \text{ As}+5(l,s) + 2.5 O_2(g) \rightarrow \text{As}_2O_5(o)$	1.0
$2 \text{ B}+3(l,s) + 1.5 O_2(g) \rightarrow \text{B}_2O_3(o)$	1.0
<ul style="list-style-type: none"> Sum Ba+2 and 137m-Ba to Ba+2 	
$\text{Ba}+2(l,s) + 0.5 O_2(g) \rightarrow \text{BaO}(o)$	1.0
$\text{Be}+2(l,s) + 0.5 O_2(g) \rightarrow \text{BeO}(o)$	1.0
$2 \text{ Bi}+3(l,s) + 1.5 O_2(g) \rightarrow \text{Bi}_2O_3(o)$	1.0
$\text{Ca}+2(l,s) + 0.5 O_2(g) \rightarrow \text{CaO}(o)$	1.0
<ul style="list-style-type: none"> Sum Cd+2 and 113m-Cd to Cd+2 	

$\text{Cd}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{CdO (o)}$	1.0
$4 \text{ Ce}+3 \text{ (l,s)} + 3 \text{ O}_2 \text{ (g)} \rightarrow 2 \text{ Ce}_2\text{O}_3 \text{ (o)}$	1.0
$\text{Cl- (l,s)} \rightarrow \text{Cl- (o)}$	1.0
• Sum 242-Cm, 243-Cm, and 244-Cm to 242-Cm	
$2 \text{ 242-Cm (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Cm}_2\text{O}_3 \text{ (o)}$	1.0
• Sum Co+3 and 60-Co to Co+3	
$2 \text{ Co}+3 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ CoO (o)}$	1.0
$2 \text{ Cr(TOTAL) (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Cr}_2\text{O}_3 \text{ (o)}$	1.0
$2 \text{ Cr(OH)}_4\text{- (l,s)} \rightarrow \text{Cr}_2\text{O}_3 \text{ (o)} + 0.5 \text{ O}_2 \text{ (g)} + 4 \text{ H}_2\text{O (g)}$	1.0
• Sum Cs+, 134-Cs, and 137-Cs to Cs+	
$2 \text{ Cs+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Cs}_2\text{O (o)}$	1.0
$\text{Cu}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{CuO (o)}$	1.0
• Sum 152-Eu, 154-Eu, and 155-Eu to 152-Eu	
$2 \text{ 152-Eu (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Eu}_2\text{O}_3 \text{ (o)}$	1.0
$\text{F- (l,s)} \rightarrow \text{F- (o)}$	1.0
$2 \text{ Fe}+3 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Fe}_2\text{O}_3 \text{ (o)}$	1.0
$\text{Hg}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{HgO (o)}$	0.0 (100 % split)
$129\text{-I (l,s)} \rightarrow 129\text{-I (o)}$	1.0
$2 \text{ K+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{K}_2\text{O (o)}$	1.0
$2 \text{ La}+3 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{La}_2\text{O}_3 \text{ (o)}$	1.0
$2 \text{ Li+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Li}_2\text{O (o)}$	1.0
$\text{Mg}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{MgO (o)}$	1.0
$2 \text{ MnO}_4\text{- (l,s)} \rightarrow 2 \text{ MnO (o)} + 3 \text{ O}_2 \text{ (g)}$	1.0
$2 \text{ Mn}+4 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ MnO (o)}$	1.0
$2 \text{ MnO}_2 \text{ (l,s)} \rightarrow 2 \text{ MnO (o)} + \text{O}_2 \text{ (g)}$	1.0
$2 \text{ Mnp (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Mnp}_2\text{O}_3 \text{ (o)}$	1.0
$\text{Mo}+6 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{MoO}_3 \text{ (o)}$	1.0
$2 \text{ Na+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Na}_2\text{O (o)}$	1.0
$2 \text{ Nap+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Nap}_2\text{O (o)}$	1.0
$2 \text{ 93m-Nb (l,s)} + 2.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Nb}_2\text{O}_5 \text{ (o)}$	1.0
$2 \text{ Nd}+3 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Nd}_2\text{O}_3 \text{ (o)}$	1.0
• Sum Ni+2, 59-Ni, and 63-Ni to Ni+2	
$\text{Ni}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{NiO (o)}$	1.0
$237\text{-Np (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{NpO}_2 \text{ (o)}$	1.0
$2 \text{ PO}_4\text{-3 (l,s)} \rightarrow \text{P}_2\text{O}_5 \text{ (o)} + 1.5 \text{ O}_2 \text{ (g)}$	1.0
$2 \text{ 231-Pa (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Pa}_2\text{O}_3 \text{ (o)}$	1.0
$\text{Pb}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{PbO (o)}$	1.0
$\text{Pd}+2 \text{ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{PdO (o)}$	1.0
$2 \text{ Pr}+3 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Pr}_2\text{O}_3 \text{ (o)}$	1.0
• Sum Pu+4, 238-Pu, 239-Pu, 240-Pu, 241-Pu, and 242-Pu to Pu+4	
$\text{Pu}+4 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{PuO}_2 \text{ (o)}$	1.0
• Sum 226-Ra and 228-Ra to 226-Ra	
$2 \text{ 226-Ra (l,s)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ RaO (o)}$	1.0
$2 \text{ Rb+ (l,s)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Rb}_2\text{O (o)}$	1.0
$2 \text{ Rh}+3 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Rh}_2\text{O}_3 \text{ (o)}$	1.0
• Sum Ru+3 and 106-Ru to Ru+3	
$\text{Ru}+3 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{RuO}_2 \text{ (o)}$	1.0
$\text{SO}_4\text{-2 (l,s)} \rightarrow \text{SO}_3 \text{ (o)} + 0.5 \text{ O}_2 \text{ (g)}$	1.0
• Sum Sb+5 and 125-Sb to Sb+5	
$2 \text{ Sb}+5 \text{ (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Sb}_2\text{O}_3 \text{ (o)}$	1.0
• Sum Se+6 and 79-Se to Se+6	
$\text{Se}+6 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{SeO}_2 \text{ (o)}$	1.0
$\text{Si}+4 \text{ (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{SiO}_2 \text{ (o)}$	1.0
$2 \text{ 151-Sm (l,s)} + 1.5 \text{ O}_2 \text{ (g)} \rightarrow \text{Sm}_2\text{O}_3 \text{ (o)}$	1.0
$126\text{-Sn (l,s)} + \text{O}_2 \text{ (g)} \rightarrow \text{SnO}_2 \text{ (o)}$	1.0

- Sum Sr+2 and 90-Sr to Sr+2

Sr+2 (l,s) + 0.5 O ₂ (g) → SrO (o)	1.0
2 Ta+5 (l,s) + 2.5 O ₂ (g) → Ta ₂ O ₅ (o)	1.0

- Sum Tc+7 and 99-Tc to Tc+7

Tc+7 (l,s) + 3.5 O ₂ (g) → Tc ₂ O ₇ (o)	1.0
Te+6 (l,s) + O ₂ (g) → TeO ₂ (o)	1.0

- Sum Th+4, 229-Th, and 232-Th to Th+4

Th+4 (l,s) + O ₂ (g) → ThO ₂ (o)	1.0
Ti+4 (l,s) + O ₂ (g) → TiO ₂ (o)	1.0
4 Tl+3 (l,s) + O ₂ (g) → 2 Tl ₂ O (o)	1.0

- Sum U(TOTAL), 232-U, 233-U, 234-U, 235-U, 236-U, and 238-U to U(TOTAL)

2 U(TOTAL) (l,s) + 3 O ₂ (g) → 2 UO ₃ (o)	1.0
2 V+5 (l,s) + 2.5 O ₂ (g) → V ₂ O ₅ (o)	1.0
W+6 (l,s) + 1.5 O ₂ (g) → WO ₃ (o)	1.0

- Sum Y+3 and 90-Y to Y+3

2 Y+3 (l,s) + 1.5 O ₂ (g) → Y ₂ O ₃ (o)	1.0
Zn+2 (l,s) + 0.5 O ₂ (g) → ZnO (o)	1.0

- Sum Zr+4 and 93-Zr to Zr+4

Zr+4 (l,s) + O ₂ (g) → ZrO ₂ (o)	1.0
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A lower set volume (1,875 gallons) is applied to the LAW melters where the molten glasses above the set volume will be transferred to the ILAW containers. LMP-MLTR-00001 transfers molten glasses to ILAW1 while LMP-MLTR-00002 transfers molten glasses to ILAW2. The ILAW containers are 564 gallons in size. ILAW glass has a 2.58 g/cm³ density. Container counts and glass compositions are tracked by the model. Gases from the melter are routed to a corresponding LAW Offgas Process system. LMP-MLTR-00001 transfers materials to LOP-SCB-00001 and LMP-MLTR-00002 transfers materials to LOP-SCB-00002.

Figures F-13 and F-14 provide graphical illustrations of the LMP/LOP systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the LMP/LOP.

4.8.16 LAW Offgas Process (LOP) Systems

Vessel Tag #	Equipment Description
LOP-SCB-00001	LAW Melter 1 Submerged Bed Scrubber
LOP-SCB-00002	LAW Melter 2 Submerged Bed Scrubber
LOP-VSL-00001	LAW Melter 1 SBS Condensate Vessel
LOP-VSL-00002	LAW Melter 2 SBS Condensate Vessel

The LAW offgas process includes two separate trains of LAW Melter Offgas Treatment Process systems and a LAW Secondary Offgas/Vessel Process system. The LAW SBSs receive offgas from a corresponding LAW melter. LOP-SCB-00001 receives materials from LMP-MLTR-00001 and LOP-SCB-00002 receives materials from LMP-MLTR-00002. Each of the LAW SBS vessels is associated with a SBS Condensate Vessel. For modeling simplicity, the condensate vessels have been merged into their associated SBSs, for example, working volumes have been combined as follows:

LOP-SCB-00001/2

Minimum Volume = 451 + 0 gallons = 451 gallons
 Maximum Volume = 6,651 + 3,329 gallons = 9,980 gallons
 Set Volume = 8,980 gallons

Maximum Accumulation Time = 48 hours

Initially, the scrubbers are filled to the heel volume with demineralized water from a chem-add. Upon arriving at the SBS, the entrained liquid and solid from the melter are split to the WESP according to the split values given in Table D-13. The remaining liquid, solid, and gas materials undergo the following reactions (reactions take place in the order presented):

Reactions	Conversion (Fraction)
$\text{H}_2\text{O (g)} \rightarrow \text{H}_2\text{O (l)} \text{ or } \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{O (g)}$	0.138 mole fraction at outlet
$\text{Hg (g)} \rightarrow \text{Hg}^{+2} \text{ (l)}$	Eq. 60
$2 \text{ B}^{+3} \text{ (s)} + 1.5 \text{ O}_2 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ H}^+ \text{ (l)} + 2 \text{ B}^{+3} \text{ (l)} + 4 \text{ O}^{2-} \text{ (l)} + 2 \text{ H}_2\text{O (l)}$	1.0
$\text{HCl (g)} \rightarrow \text{Cl}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.8588
$\text{HF (g)} \rightarrow \text{F}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.8384
$3 \text{ NO}_2 \text{ (g)} + \text{H}_2\text{O (l)} \rightarrow 2 \text{ NO}_3^- \text{ (l)} + 2 \text{ H}^+ \text{ (l)} + \text{NO (g)}$	0.002
$4 \text{ NO (g)} + 2 \text{ H}_2\text{O (l)} + 3 \text{ O}_2 \text{ (g)} \rightarrow 4 \text{ NO}_3^- \text{ (l)} + 4 \text{ H}^+ \text{ (l)}$	0.0548
$\text{P}_2\text{O}_5 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 0.5 \text{ PO}_4^{3-} \text{ (l)} + 1.5 \text{ PO}_4^{3-} \text{ (s)} + 6 \text{ H}^+ \text{ (l)}$	0.6
$\text{SO}_2 \text{ (g)} + \text{H}_2\text{O (l)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{SO}_4^{2-} \text{ (l)} + 2 \text{ H}^+ \text{ (l)}$	0.8721
$\text{C}_2\text{H}_3\text{N (g)} \rightarrow \text{C}_2\text{H}_3\text{N (l)}$	0.8
$\text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (g)} \rightarrow \text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (l)}$	0.8837
$129\text{-I (g)} \rightarrow 129\text{-I (l)}$	0.7980
$\text{Na}^+ \text{ (s)} + \text{Cl}^- \text{ (s)} \rightarrow \text{Na}^+ \text{ (l)} + \text{Cl}^- \text{ (l)}$	1.0 $[\text{Cl}^-] \text{ (s)} = 0.0$
$\text{Nap}^+ \text{ (s)} + \text{Cl}^- \text{ (s)} \rightarrow \text{Nap}^+ \text{ (l)} + \text{Cl}^- \text{ (l)}$	1.0 $[\text{Cl}^-] \text{ (s)} = 0.0$
$\text{Na}^+ \text{ (s)} + \text{F}^- \text{ (s)} \rightarrow \text{Na}^+ \text{ (l)} + \text{F}^- \text{ (l)}$	1.0 $[\text{F}^-] \text{ (s)} = 0.0$
$\text{Nap}^+ \text{ (s)} + \text{F}^- \text{ (s)} \rightarrow \text{Nap}^+ \text{ (l)} + \text{F}^- \text{ (l)}$	1.0 $[\text{F}^-] \text{ (s)} = 0.0$
$4 \text{ Na}^+ \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Na}^+ \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	1.0
$4 \text{ Nap}^+ \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Nap}^+ \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	1.0
$4 \text{ K}^+ \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ K}^+ \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	1.0
$2 \text{ Ca}^{+2} \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ Ca}^{+2} \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	0.3
$2 \text{ Sr}^{+2} \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ Sr}^{+2} \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	0.5
$2 \text{ }^{90}\text{-Sr (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ }^{90}\text{-Sr (s)} + 4 \text{ OH}^- \text{ (l)}$	0.5
$4 \text{ Li}^+ \text{ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Li}^+ \text{ (l)} + 4 \text{ OH}^- \text{ (l)}$	1.0
$\text{NH}_3 \text{ (g)} \rightarrow \text{NH}_3 \text{ (l)}$	0.90
$\text{NH}_3 \text{ (l)} + \text{H}_2\text{O (l)} \rightarrow \text{NH}_4^+ \text{ (l)} + \text{OH}^- \text{ (l)}$	Eq. 68
$\text{CO}_2 \text{ (g)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{CO}_3 \text{ (l)}$	0.001
$\text{H}_2\text{CO}_3 \text{ (l)} \rightarrow \text{HCO}_3^- \text{ (l)} + \text{H}^+ \text{ (l)}$	Eq. 64
$\text{HCO}_3^- \text{ (l)} \rightarrow \text{CO}_3^{2-} \text{ (l)} + \text{H}^+ \text{ (l)}$	Eq. 65
$\text{H}^+ \text{ (l)} + \text{OH}^- \text{ (l)} \rightarrow \text{H}_2\text{O (l)}$	1.0

Conversion factor of the mercury reaction is dependent upon the mercury to chloride ratio in the LAW melter feed, for example,

$$\begin{aligned}
 \text{CF} &= 0.833 && \text{if } \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} \leq 0.1 \\
 &= 0.559 && \text{if } 0.1 < \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} \leq 0.5 \\
 &= 0.286 && \text{if } \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} > 0.5
 \end{aligned}
 \tag{Eq. 60}$$

The remaining gaseous mercury continues on as “Hg” to the downstream LOP/LVP equipment. The SBS split values for $\text{Hg}^{+2} \text{ (l, s)}$ are set to zero.

Conversion factors for the H_2CO_3 (l) and HCO_3^- (l) reactions are calculated below:

$$[\text{Total}] = 0.001 \times [\text{gmols of CO}_2 \text{ (g)}] / (\text{volume above setpoint in liters}) \quad (\text{Eq. 61})$$

$$[\text{H}_2\text{CO}_3]\text{-End} = 0.1834 \times [\text{Total}] \quad (\text{Eq. 62})$$

$$[\text{HCO}_3^-]\text{-End} = 0.8162 \times [\text{Total}] \quad (\text{Eq. 63})$$

$$\text{H}_2\text{CO}_3\text{-CF} = ([\text{H}_2\text{CO}_3]\text{-Begin} - [\text{H}_2\text{CO}_3]\text{-End}) / [\text{H}_2\text{CO}_3]\text{-Begin} \quad (\text{Eq. 64})$$

$$\text{HCO}_3\text{-CF} = ([\text{HCO}_3^-]\text{-Begin} - [\text{HCO}_3^-]\text{-End}) / [\text{HCO}_3^-]\text{-Begin} \quad (\text{Eq. 65})$$

The conversion factor for the NH_4^+ reaction is calculated using the equilibrium constant as

$$[\text{Total}] = 0.9 \times [\text{gmols of NH}_3 \text{ (g)}] / (\text{volume above setpoint in liters}) \quad (\text{Eq. 66})$$

$$[\text{NH}_3]\text{-End} = 5.682\text{e-}3 \times [\text{Total}] \quad (\text{Eq. 67})$$

$$\text{NH}_4\text{-CF} = ([\text{NH}_3]\text{-Begin} - [\text{NH}_3]\text{-End}) / [\text{NH}_3]\text{-Begin} \quad (\text{Eq. 68})$$

The production of NH_3 (g) from the melter is dependent upon the pH value at the SBS at the end of the above reactions. Initially, the multiplier M of the stoichiometric coefficients for Eq. 54 and Eq. 55 is set to 1.0. The M value is increased if pH at the SBS is below 7.0 and is decreased if pH is above 7.0. This provides the means for achieving a pH 7.0 at the SBS by adjusting the production of NH_3 at the melter. Due to the delay effect of the above modeling approach, the following chemical reactions are used to provide further adjustment.

if pH < 7.0 then

$10 \text{ H}^+ \text{ (l)} + \text{NO}_3^- \text{ (l)} \rightarrow \text{NH}_4^+ \text{ (l)} + 3 \text{ H}_2\text{O (l)}$	until H^+ or NO_3^- are consumed
$8 \text{ H}^+ \text{ (l)} + \text{NO}_2 \text{ (l)} \rightarrow \text{NH}_4^+ \text{ (l)} + 2 \text{ H}_2\text{O (l)}$	until H^+ or NO_2^- are consumed

if pH > 7.0 then

$\text{NH}_4^+ \text{ (l)} + 2 \text{ H}_2\text{O} \rightarrow \text{NO}_2^- \text{ (l)} + 8 \text{ H}^+$	until pH = 7.0 or NH_4^+ is consumed
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It shall be noted that the pH control measures above are a modeling technique used to approximate the experimental data, which indicated a near pH neutral environment in the SBS.

H_2O is condensed or evaporated based on the mole fraction of H_2O in the offgas stream exiting the LAW SBS. The goal is to have a mole fraction of 0.138 H_2O (g) in the offgas stream. When feed is unavailable to the melter, water vapor entering the SBS is dramatically reduced causing the water in SBS to evaporate. Under this circumstance, the SBS water chem-add will be utilized to replenish the scrubber column. Tritium (^3H) and peroxide (H_2O_2) follow water, e.g., splits are dynamically calculated in every time step based on the water condensation or evaporation situations.

The SBS volume is reset after the reactions. LOP-SCB-00001 transfers the offgas to LOP-WESP-00001 while LOP-SCB-00002 transfers to LOP-WESP-00002. A SBS will accumulate condensate until either

the set volume or the 48-hour maximum accumulation time has been reached. The SBS discharges the condensate to RLD-VSL-00005 if the vessel is ready to receive, or continue to cumulate while waiting for RLD-VSL-00005 to become ready. A 1000-gallon headspace (e.g., $V_{\max} - V_{\text{set}}$) is reserved for each SBS to allow buffer for continuous operations.

Vessel Tag #	Equipment Description
LOP-WESP-00001	LAW Wet Electrostatic Precipitator
LOP-WESP-00002	LAW Wet Electrostatic Precipitator

Gases that exit the LAW SBS are routed to a corresponding LAW WESP. LOP-WESP-00001 receives the offgas from LOP-SCB-00001 and LOP-WESP-00002 receives the offgas from LOP-SCB-00002. Upon arriving at the WESP, the entrained liquid and solid from the SBS are split to LVP-HEPA-00001AB, via LAW-Vessel-Vent, according to the split values given in Table D-14. Demin water is pumped to the WESP through a chem-add at a rate of 0.75 gpm based on 15 metric tons of glass per day (MTG/day) melter operation. The rate is proportioned to the melter production rate if ramp up occurs. In addition, air is added to the WESP to ensure that the electrodes stay dry and clean. For modeling purposes, this air is combined with the LAW Vessel Vent air stream. The total air injected is 368 cfm at 118.3 °F and 14.7 psi.

The LAW WESP performs the following reactions:

Reactions	Conversion (Fraction)
$\text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{O (g)}$ or $\text{H}_2\text{O (g)} \rightarrow \text{H}_2\text{O (l)}$	0.163 mole fraction at outlet
$\text{HCl (g)} \rightarrow \text{Cl}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.2308
$\text{HF (g)} \rightarrow \text{F}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.4764
$129\text{-I (g)} \rightarrow 129\text{-I (l)}$	0.1071
$\text{SO}_2 \text{ (g)} + \text{H}_2\text{O (l)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{SO}_4\text{-2 (l)} + 2 \text{ H}^+ \text{ (l)}$	0.9471
$\text{P}_2\text{O}_5 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 6 \text{ H}^+ \text{ (l)} + 0.5 \text{ PO}_4\text{-3 (l)} + 1.5 \text{ PO}_4\text{-3 (s)}$	0.8
$2 \text{ NO (g)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ H}_2\text{O (l)} + 4 \text{ H}^+ \text{ (l)} + 2 \text{ NO}_3^- \text{ (l)}$	0.01
$\text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (g)} \rightarrow \text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (l)}$	0.0909
$2 \text{ B+3 (s)} + 1.5 \text{ O}_2 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ H}^+ \text{ (l)} + 2 \text{ B+3 (l)} + 4 \text{ O-2 (l)} + 2 \text{ H}_2\text{O (l)}$	1.0
$\text{H}^+ \text{ (l)} + \text{OH}^- \text{ (l)} \rightarrow \text{H}_2\text{O (l)}$	1.0

H₂O is evaporated or condensed based on the mole fraction of H₂O in the offgas stream exiting the LAW WESP. The goal is to have a mole fraction of 0.163 H₂O (g) in the offgas stream. Tritium and peroxide follow water. The remaining gases exit the WESP and pass to the LAW HEPA while the liquid and solid flow to RLD-VSL-00004.

Vessel Tag #	Equipment Description
LVP-HEPA-00001AB	LAW High Efficiency Particular Air Filter

Gases leaving the LAW WESP are combined with an air stream that models the LAW Vessel Vent and are routed to the LAW HEPA. A large percentage of the liquid and solid components entering the LAW HEPA are captured while few of the gas components are removed. The offgas leaving the HEPA is routed to the downstream Carbon Absorber. Percent removal by the HEPA is shown in Table D-15.

Vessel Tag #	Equipment Description
LVP-ADBR-00001AB	LAW Carbon Absorber

The LAW Carbon Absorber captures 99.585% of mercury from the entrained liquid and solid. It also removes 99% of the 129-I and 96.997% of the HCl and HF from the gas stream. The offgas leaving the absorber is routed to the downstream Catalytic Oxidizer Reducer. Percent removal by the carbon absorber is shown in Table D-16.

Vessel Tag #	Equipment Description
LVP-SCR-00001-2	Catalytic Oxidizer Reducer

The primary purpose of the Catalytic Oxidizer Reducer is to remove NO and NO₂ from the offgas. SO₂, C₂H₃N, and C₁₂H₄Cl₆ are also reduced. Upon arriving at the Catalytic Oxidizer Reducer, entrained liquid and solid are removed according to the split values given in Table D-17. Pure anhydrous ammonia gas and dilution air are pumped in from the gas chem-adds named AMR-VSL-00001-2-NH₃ and AMR-VSL-00001-2-AIR, respectively. The Catalytic Oxidizer Reducer performs the following reactions:

Reactions	Conversion (Fraction)
4 NO (g) + 4 NH ₃ (g) + O ₂ (g) → 4 N ₂ (g) + 6 H ₂ O (g)	0.98
2 NO ₂ (g) + 4 NH ₃ (g) + O ₂ (g) → 3 N ₂ (g) + 6 H ₂ O (g)	0.98
SO ₂ (g) + 0.5 O ₂ (g) → SO ₃ (g)	0.95
C ₂ H ₃ N (l,g) + 3.75 O ₂ (g) → 2 CO ₂ (g) + 1.5 H ₂ O (g) + NO ₂ (g)	0.757
C ₁₂ H ₄ Cl ₆ (l,g) + 11.5 O ₂ (g) + H ₂ O (g) → 12 CO ₂ (g) + 6 HCl (g)	0.95

The quantity of gas chem-add is dynamically determined to satisfy the stoichiometric requirements of the NO_x reactions, the NH₃ in the inlet to the Catalytic Oxidizer Reducer including the gas, liquid, and solid phases, and a 78 parts per million volume (ppmv) slip stream amount. The exiting gas is routed to the LAW Caustic Scrubber.

Vessel Tag #	Equipment Description
LVP-SCB-00001	Caustic Scrubber
LVP-TK-00001	Caustic Collection Vessel

The Caustic Scrubber is modeled as two parts. The column (LVP-SCB-00001) is modeled in the LAW Offgas Treatment System. The vessel (LVP-TK-00001) is modeled in the LAW Liquid Effluent workspace. Upon arriving at the Caustic Scrubber, the entrained liquid and solid from the Catalytic Oxidizer Reducer are split to the Stack according to the split values given Table D-18. Caustic solutions at pH 9 or above are pumped in from LVP-TK-00001 at 60 gpm flowrate. Reactions take place as follows:

Reactions	Conversion (Fraction)
H ₂ O (l) → H ₂ O (g) or H ₂ O (g) → H ₂ O (l)	0.189 mole fraction at outlet
CO ₂ (g) + H ₂ O (l) → H ₂ CO ₃ (l)	0.004
H ₂ CO ₃ (l) → HCO ₃ ⁻ (l) + H ⁺ (l)	Eq. 64
HCO ₃ ⁻ (l) → CO ₃ ²⁻ (l) + H ⁺ (l)	Eq. 65
NH ₃ (g) → NH ₃ (l)	0.2857
NH ₃ (l) + H ₂ O (l) → NH ₄ ⁺ (l) + OH ⁻ (l)	Eq. 68
HCl (g) → Cl ⁻ (l) + H ⁺ (l)	0.99
HF (g) → F ⁻ (l) + H ⁺ (l)	0.9874
3 NO ₂ (g) + H ₂ O (l) → 2 NO ₃ ⁻ (l) + 2 H ⁺ (l) + NO (g)	0.2248
4 NO (g) + 2 H ₂ O (l) + 3 O ₂ (g) → 4 NO ₃ ⁻ (l) + 4 H ⁺ (l)	0.2248
P ₂ O ₅ (g) + 3 H ₂ O (l) → 0.5 PO ₄ ³⁻ (l) + 1.5 PO ₄ ³⁻ (s) + 6 H ⁺ (l)	0.5
SO ₂ (g) + H ₂ O (l) + 0.5 O ₂ (g) → SO ₄ ²⁻ (l) + 2 H ⁺ (l)	0.97
SO ₃ (g) + H ₂ O (l) → 2 H ⁺ (l) + SO ₄ ²⁻ (l)	0.97

Reactions	Conversion (Fraction)
129-I (g) → 129-I (l)	0.0 (reserved reaction)
H ⁺ (l) + OH ⁻ (l) → H ₂ O (l)	1.0

H₂O is evaporated or condensed based on the mole fraction of H₂O in the offgas stream exiting the LAW Caustic Scrubber. The goal is to have a mole fraction of 0.189 H₂O (g) in the offgas stream. Gases are transferred to the Stack while liquid and solid are recycled to LVP-TK-00001.

LVP-TK-00001 is initially filled to halfway between its set volume (6,032 gallons) and its minimum volume (2,032 gallons) with NapOH to pH 9.0. The goal is to keep pH at constant at around 9.0. Within each time step, H⁺ is produced from the Caustic Scrubber reactions that lower the pH value. If the pH in the vessel goes below 9.0, 20 gallons of 5M NapOH will be added (minimum pump capacity) which brings the pH to above 9.0. If the SpG goes above 1.1 as heavier components accumulate, demin water will be added at 22 gpm flowrate. If the volume goes above its set volume, the vessel will be discharged to its minimum volume. If the volume goes below 4,032 gallons (water is lost in the caustic scrubber column due to evaporation) even if its SpG is below the 1.1 target volume, water will be added to replenish the vessel. The vessel will be discharged anyway if it has not been discharged for a month.

When the level in LVP-TK-00001 reaches the set volume, the contents are transferred to either RLD-VSL-00017A or RLD-VSL-00017B, depending on their availability. If RLD-VSL-00017A and RLD-VSL-00017B are not available, then LVP-TK-00001 continues to fill to maximum volume. If the maximum volume is reached and LVP-TK-00001 still does not have anywhere to transfer, the LAW melters will idle until LVP-TK-00001 can empty. LVP-TK-00001 still pumps to and receives from the LAW Caustic Scrubber Column while it is emptying.

Figure F-15 provides a graphical illustration of the LVP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the LVP.

4.8.17 HLW Melter Feed Process (HFP) System

Vessel Tag #	Equipment Description
HFP-VSL-00001	HLW Melter Feed Preparation Vessel
HFP-VSL-00005	HLW Melter Feed Preparation Vessel

The HLW Melter Feed Preparation Vessels (HLW MFPV) receive waste feed from HLP-VSL-00028 on a batch transfer basis and alternate with each other in operation. When a HLW MFPV becomes empty, a glass former analysis will be performed which determines the batch size and glass former recipe based on the chemical compositions in HLP-VSL-00028 so that the following conditions are met:

- 1) HFP-VSL-00001 and HFP-VSL-00005 will not exceed the maximum volume after waste, line flush, glass formers, dusting water, and rheology water are added
- 2) Rheology water target is met (550 grams oxide/L)
- 3) HLW glass quality specifications are met

The MFPV batch size is determined using the logic shown in Figure 15. The glass former recipe is determined using the HLW Glass Shell V2.0 presented in Figures 16 through 34. Details for the development of this HLW Glass Shell can be found in 24590-WTP-MCR-PET-09-0047 and further in the *BARD*. A request is submitted to the HLW recipe queue for the Glass Former Reagent System. Glass

formers can be prepared as soon as a recipe exists in the HLW recipe queue given that the GFR is available. LAW and HLW recipes compete for the use of GFR as there is only one in the plant (refer to Section 4.8.22 for GFR operations). HLW recipes have higher priorities than the LAW recipes to prevent HFP from backing up the ultrafiltration operations.

Glass former preparations can occur simultaneously with a waste batch transfer. When an HLW MFPV has reached its set volume, it receives a line flush and a pre-determined volume of rheology water. Then the vessel is held 12.79 hours for a pre-glass former sampling. The vessel will wait for the glass formers if they are not already ready. HFP-VSL-00001 receives glass formers from GFR-TK-00031 and HFP-VSL-00005 receives glass formers from GFR-TK-00025. The MFPV will receive 48 gallons of demister flush water before the confirmation sample is taken. The vessel is held 9.59 hours for a confirmation sampling prior to discharge. HFP-VSL-00001 empties its contents to HFP-VSL-00002 and HFP-VSL-00005 empties its contents to HFP-VSL-00006. After emptying, the HLW MFPV starts a new cycle.

Figure 16 IHLW Glass Shell (Part 1)

Figure 17 IHLW Glass Shell (Part 2)

Figure 18 IHLW Glass Shell (Part 3)

Figure 19 IHLW Glass Shell (Part 4)

Figure 20 IHLW Glass Shell (Part 5)

Figure 21 IHLW Glass Shell (Part 6)

Figure 22 IHLW Glass Shell (Part 7)

Figure 23 IHLW Glass Shell (Part 8)

Figure 24 IHLW Glass Shell (Part 9)

Figure 25 IHLW Glass Shell (Part 10)

Figure 26 IHLW Glass Shell (Part 11)

Figure 27 IHLW Glass Shell (Part 12)

Figure 28 IHLW Glass Shell (Part 13)

Figure 29 IHLW Glass Shell (Part 14)

Figure 30 IHLW Glass Shell (Part 15)

Figure 31 IHLW Glass Shell (Part 16)

Figure 32 IHLW Glass Shell (Part 17)

Figure 33 IHLW Glass Shell (Part 18)

Figure 34 IHLW Glass Shell (Part 19)

The glass former recipe, including the quantities of borax, boric acid, kyanite, lithium carbonate, olivine, rutile, soda ash, sugar, wollastonite, zinc oxide, and zircon sand, are returned from the Immobilized High-Level Waste (IHLW) Glass Shell.

Vessel Tag #	Equipment Description
HFP-VSL-00002	HLW Melter 1 Feed Vessel
HFP-VSL-00006	HLW Melter 2 Feed Vessel

The HLW MFVs receive feed from the corresponding HLW MFPVs. HFP-VSL-00002 transfers material only to HMP-MLTR-00001, and HFP-VSL-00006 transfers material only to HMP-MLTR-00002. The objective of the MFVs is to feed enough waste to the melters to maintain a set target production rate for MTG/day. Because the composition of the waste batches are variable, the transfer rate required to maintain the target throughput in the melters is also variable. A more diluted feed will have a higher transfer rate so that the target melter production rate can be maintained. When an HLW MFV reaches its lower setpoint (1,563 gallons) it becomes available to receive feed again while continuing to empty to its minimum volume (1,543 gallons). This prevents the HLW melter from becoming idle. The only time that an HLW MFV will stop pumping to the melter is when there is no feed available from the HLW MFPV and the HLW MFV is at its minimum volume.

The HLW melter feed pumps will be shut down temporarily when the number of canisters on the canister decontamination system cooling rack reach the 24 capacity limit and/or when RLD-VSL-00007 is filled but unable to discharge. The melter feed pumps resume as soon as the restricting conditions are relieved.

Figure F-18 provides the graphical illustration of the HFP system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the HFP.

4.8.18 HLW Melter Process (HMP) System

Vessel Tag #	Equipment Description
HMP-MLTR-00001	HLW Melter 1
HMP-MLTR-00002	HLW Melter 2

HLW Melters (HMP-MLTR-00001 and HMP-MLTR-00002) are used to transform the HLW into glass. Liquid and solid wastes, oxide glass formers and impurities, and air are delivered to the melters. The inflow of wastes and glass formers depends on the availability of feed; however, the inflow of air is continuous once started. The air stream is made up of: 1) air inleakage, 2) bubbler air, 3) film cooler air, and 4) pressure control air. The combined air flowrate and the associated temperature and pressure are shown in Table B-19.

When feed enters the melter, a split is applied to the non-gas components including the liquid and solid wastes, and oxide glass formers and associated mineral impurities. The liquid split values apply to the liquid components that come into the melter while the solid split values apply to the combined solids of solid wastes, oxide glass formers, and impurities. The predefined split values are shown in Table D-19. Exceptions are applied to the following components of which melter reactions or a combination of melter reactions and splits are more appropriate:

Components	Liquid % to SBS	Solid% to SBS	Descriptions
129-I	0.000	0.000	129-I (l,s) $\rightarrow$ 129-I (g) CF = 0.7692, remaining go to glass
3-H	100.000	100.000	Follows water, 100% go to offgas
C12H4Cl6	0.000	0.000	C12H4Cl6 (l,s) + 11.5 O2 (g) + H2O (l) $\rightarrow$ 12 CO2 (g) + 6 HCl (g) CF = 1.0
C2H3N	0.000	0.000	C2H3N (l,s) + 3.75 O2 (g) $\rightarrow$ 2 CO2 (g) + 1.5 H2O (g) + NO2 (g) CF = 1.0
C2O4-2	0.000	0.000	C2O4-2 (l,s) $\rightarrow$ 2 CO2 (g) CF = 1.0
CHO2-	0.000	0.000	CHO2- (l,s) + 0.25 O2 (g) $\rightarrow$ CO2 (g) + 0.5 H2O (g) CF = 1.0
Cl-	0.000	0.000	2 Cl- (l,s) + 2 Na+ (l,s) + H2O (l) $\rightarrow$ Na2O (o) + 2 HCl (g) CF = 0.7353, remaining go to glass
CN-	1.695	1.695	2 CN- (l,s) + 2 O2 (g) $\rightarrow$ 2 CO2 (g) + N2 (g), CF = 1.0, partially split to offgas, remaining 100% destroyed
CO3-2	0.000	0.000	CO3-2 (l,s) $\rightarrow$ CO2 (g) + 0.5 O2 (g) CF = 1.0
F-	0.000	0.000	2 F- (l,s) + 2 Na+ (l,s) + H2O (l) $\rightarrow$ Na2O (o) + 2 HF (g) CF = 0.8065, remaining go to glass
H+	0.000	0.000	H+ (l,s) + OH(BOUND) (l,s) $\rightarrow$ H2O (g) CF = 1.0
H2CO3	0.000	0.000	H2CO3 (l,s) $\rightarrow$ CO2 (g) + H2O (g) CF = 1.0
H2O	0.000	0.000	H2O (l,s) $\rightarrow$ H2O (g) CF = 1.0
H2O2	0.000	0.000	2 H2O2 (l,s) $\rightarrow$ 2 H2O (g) + O2 (g) CF = 1.0
HCO3-	0.000	0.000	2 HCO3- (l,s) $\rightarrow$ 2 CO2 (g) + H2O (g) + 0.5 O2 (g) CF = 1.0
NH3	0.000	0.000	2 NH3 (l,s) + 3 O2 (g) $\rightarrow$ NO (g) + NO2 (g) + 3 H2O (g) CF = 1.0
NH4+	0.000	0.000	2 NH4+ (l,s) + 3.5 O2 (g) $\rightarrow$ NO (g) + NO2 (g) + 4 H2O (g) CF 1.0
NO2-	0.000	0.000	Eq. 55
NO3-	0.000	0.000	Eq. 54
O-2	0.000	0.000	2 O-2 (l,s) $\rightarrow$ O2 (g) CF = 1.0
OH(BOUND)	0.000	0.000	2 OH(Bound) (l,s) $\rightarrow$ H2O (g) + 0.5 O2 (g) CF = 1.0
OH-	0.000	0.000	2 OH- (l,s) $\rightarrow$ H2O (g) + 0.5 O2 (g) CF = 1.0
SO4-2	0.000	0.000	SO4-2 (l,s) $\rightarrow$ SO2 (g) + O2 (g), CF = 0.5814, remaining is oxidized and go to glass
TOC	0.000	0.000	TOC (l,s) + O2 (g) $\rightarrow$ CO2 (g) CF = 1.0

Nitrate and nitrite decomposition reactions are shown as Eq. 54 and Eq. 55 where the stoichiometric coefficients are dependent upon the variable multiplier M. These reactions provide the means for approximating the experimental results which found the SBS solution to be near neutral (pH = 6.5 to 7.5) due to variations of ammonia gas production rate. Refer to Section 4.8.15 for detailed discussions on nitrate and nitrite decomposition reactions.

The splits of sulfate include SO4-2 (l,s) to the offgas, SO2 (g) to the offgas, and SO3 (o) to the glass. The overall split to the offgas is 33.3% of which 6.25% is SO4-2 (l,s) and 93.75% is SO2 (g). This is equivalent to: a) 2.08125% of the melter feed sulfate being split to the SBS as SO4-2 (l,s), b) 31.8823% of the melter feed sulfate being converted to SO2 (g) that goes to the SBS, and c) 66.7% of the melter feed sulfate is oxidized to SO3 (o) that goes to the glass.

After splitting to the offgas system, the remaining solid and liquid arrays are combined in the liquid array and the following reactions occur in each melter, reactions take place in the order presented (note that some reactions have been shown in the table above).

Organic Destruction Reactions	Conversion (Fraction)
14-C (l,s) + O ₂ (g) → CO ₂ (g)	0.0 (14-C is 100% split)
TOC (l,s) + O ₂ (g) → CO ₂ (g)	1.0
C ₁₂ H ₄ Cl ₆ (l,s) + 11.5 O ₂ (g) + H ₂ O (l) → 12 CO ₂ (g) + 6 HCl (g)	1.0
C ₂ H ₃ N (l,s) + 3.75 O ₂ (g) → 2 CO ₂ (g) + 1.5 H ₂ O (g) + NO ₂ (g)	1.0
C ₂ O ₄ -2 (l,s) → 2 CO ₂ (g)	1.0
CHO ₂ - (l,s) + 0.25 O ₂ (g) → CO ₂ (g) + 0.5 H ₂ O (g)	1.0
PPG (l,s) + 240 O ₂ (g) → 180 CO ₂ (g) + 181 H ₂ O (g)	1.0
DPPG (l,s) + 240 O ₂ (g) → 180 CO ₂ (g) + 181 H ₂ O (g)	1.0
PDMS (l,s) + 1892 O ₂ (g) → 946 CO ₂ (g) + 1419 H ₂ O (g) + 472 SiO ₂ (o)	1.0
DPDMS (l,s) + 1892 O ₂ (g) → 946 CO ₂ (g) + 1419 H ₂ O (g) + 472 SiO ₂ (o)	1.0

Miscellaneous Reactions	Conversion (Fraction)
2 Cl- (l,s) + 2 Na+ (l,s) + H ₂ O (l) → Na ₂ O (o) + 2 HCl (g)	0.7353
2 F- (l,s) + 2 Na+ (l,s) + H ₂ O (l) → Na ₂ O (o) + 2 HF (g)	0.8065
129-I (l,s) → 129-I (g)	0.7692
Hg+2 (l, s) → Hg (g)	1.0
r11×NO ₃ ⁻ (l,s) + r12×H ₂ O (l) → p11×N ₂ (g) + p12×NO (g) + p13×NO ₂ (g) + p14×NH ₃ (g) + (0.25+p15)×O ₂ (g)	dynamically calculated
r21×NO ₂ ⁻ (l,s) + r22×H ₂ O (l) → p21×N ₂ (g) + p22×NO (g) + p23×NO ₂ (g) + p24×NH ₃ (g) + (0.25+p25)×O ₂ (g)	dynamically calculated
SO ₄ -2 (l,s) → SO ₂ (g) + O ₂ (g)	0.318823
C ₁₂ H ₂₂ O ₁₁ (o) + 8 NO ₃ - (l,s) → 6 C ₂ H ₃ N (g) + 2 H ₂ O (g) + N ₂ (g) + 16.5 O ₂ (g)	0.0159
C ₁₂ H ₂₂ O ₁₁ (o) + 6 HCl (g) + 0.5 O ₂ (g) → C ₁₂ H ₄ Cl ₆ (g) + 12 H ₂ O (g)	3.79e-10
C ₁₂ H ₂₂ O ₁₁ (o) + 8 NO ₃ - (l,s) → 12 CO ₂ (g) + 11 H ₂ O (g) + 4 N ₂ (g)	0.6
C ₁₂ H ₂₂ O ₁₁ (o) + 8 NO ₂ (l,s) + 4 O ₂ (g) → 12 CO ₂ (g) + 11 H ₂ O (g) + 4 N ₂ (g)	1.0
C ₁₂ H ₂₂ O ₁₁ (o) + 12 O ₂ (g) → 12 CO ₂ (g) + 11 H ₂ O (g)	1.0
2 CN- (l,s) + 2 O ₂ (g) → 2 CO ₂ (g) + N ₂ (g)	1.0
CO ₃ -2 (l,s) → CO ₂ (g) + 0.5 O ₂ (g)	1.0
H+ (l,s) + OH(BOUND) (l,s) → H ₂ O (g)	1.0
H ₂ O (l,s) → H ₂ O (g)	1.0
2 H ₂ O ₂ (l,s) → 2 H ₂ O (g) + O ₂ (g)	1.0
2 HCO ₃ - (l,s) → 2 CO ₂ (g) + H ₂ O (g) + 0.5 O ₂ (g)	1.0
H ₂ CO ₃ (l,s) → CO ₂ (g) + H ₂ O (g)	1.0
2 NH ₃ (l,s) + 3 O ₂ (g) → NO (g) + NO ₂ (g) + 3 H ₂ O (g)	1.0
2 NH ₄ ⁺ (l,s) + 3.5 O ₂ (g) → NO (g) + NO ₂ (g) + 4 H ₂ O (g)	1.0
2 O-2 (l,s) → O ₂ (g)	1.0
• Sum OH- and OH(BOUND) to OH- (i.e., combine both components into OH-)	
2 OH- (l,s) → H ₂ O (g) + 0.5 O ₂ (g)	1.0

Oxidation Reactions	Conversion (Fraction)
2 227-Ac (l,s) + 1.5 O ₂ (g) → Ac ₂ O ₃ (o)	1.0
2 Ag+ (l,s) + 0.5 O ₂ (g) → Ag ₂ O (o)	1.0
2 Al+3 (l,s) + 1.5 O ₂ (g) → Al ₂ O ₃ (o)	1.0
2 Al(OH) ₄ - (l,s) → Al ₂ O ₃ (o) + 0.5 O ₂ (g) + 4 H ₂ O (g)	1.0
2 Al(OH) ₃ (l,s) → Al ₂ O ₃ (o) + 3 H ₂ O (g)	1.0
• Sum 241-Am and 243-Am to 241-Am	
2 241-Am (l,s) + 1.5 O ₂ (g) → Am ₂ O ₃ (o)	1.0
2 As+5 (l,s) + 2.5 O ₂ (g) → As ₂ O ₅ (o)	1.0
2 B+3 (l,s) + 1.5 O ₂ (g) → B ₂ O ₃ (o)	1.0
• Sum Ba+2 and 137m-Ba to Ba+2	
Ba+2 (l,s) + 0.5 O ₂ (g) → BaO (o)	1.0
Be+2 (l,s) + 0.5 O ₂ (g) → BeO (o)	1.0
2 Bi+3 (l,s) + 1.5 O ₂ (g) → Bi ₂ O ₃ (o)	1.0

Ca+2 (l,s) + 0.5 O2 (g) → CaO (o)	1.0
• Sum Cd+2 and 113m-Cd to Cd+2	
Cd+2 (l,s) + 0.5 O2 (g) → CdO (o)	1.0
4 Ce+3 (l,s) + 3 O2 (g) → 2 Ce2O3 (o)	1.0
Cl- (l,s) → Cl- (o)	1.0
• Sum 242-Cm, 243-Cm, and 244-Cm to 242-Cm	
2 242-Cm (l,s) + 1.5 O2 (g) → Cm2O3 (o)	1.0
• Sum Co+3 and 60-Co to Co+3	
2 Co+3 (l,s) + O2 (g) → 2 CoO (o)	1.0
2 Cr(TOTAL) (l,s) + 1.5 O2 (g) → Cr2O3 (o)	1.0
2 Cr(OH)4- (l,s) → Cr2O3 (o) + 0.5 O2 (g) + 4 H2O (g)	1.0
• Sum Cs+, 134-Cs, and 137-Cs to Cs+	
2 Cs+ (l,s) + 0.5 O2 (g) → Cs2O (o)	1.0
Cu+2 (l,s) + 0.5 O2 (g) → CuO (o)	1.0
• Sum 152-Eu, 154-Eu, and 155-Eu to 152-Eu	
2 152-Eu (l,s) + 0.5 O2 (g) → Eu2O3 (o)	1.0
F- (l,s) → F- (o)	1.0
2 Fe+3 (l,s) + 1.5 O2 (g) → Fe2O3 (o)	1.0
Hg+2 (l,s) + 0.5 O2 (g) → HgO (o)	0.0 (100 % split)
129-I (l,s) → 129-I (o)	1.0
2 K+ (l,s) + 0.5 O2 (g) → K2O (o)	1.0
2 La+3 (l,s) + 1.5 O2 (g) → La2O3 (o)	1.0
2 Li+ (l,s) + 0.5 O2 (g) → Li2O (o)	1.0
Mg+2 (l,s) + 0.5 O2 (g) → MgO (o)	1.0
2 MnO4- (l,s) → 2 MnO (o) + 3 O2 (g)	1.0
2 Mn+4 (l,s) + O2 (g) → 2 MnO (o)	1.0
2 MnO2 (l,s) → 2 MnO (o) + O2 (g)	1.0
2 Mnp (l,s) + 1.5 O2 (g) → Mnp2O3 (o)	1.0
Mo+6 (l,s) + 1.5 O2 (g) → MoO3 (o)	1.0
2 Na+ (l,s) + 0.5 O2 (g) → Na2O (o)	1.0
2 Nap+ (l,s) + 0.5 O2 (g) → Nap2O (o)	1.0
2 93m-Nb (l,s) + 2.5 O2 (g) → Nb2O5 (o)	1.0
2 Nd+3 (l,s) + 1.5 O2 (g) → Nd2O3 (o)	1.0
• Sum Ni+2, 59-Ni, and 63-Ni to Ni+2	
Ni+2 (l,s) + 0.5 O2 (g) → NiO (o)	1.0
237-Np (l,s) + O2 (g) → NpO2 (o)	1.0
2 PO4-3 (l,s) → P2O5 (o) + 1.5 O2 (g)	1.0
2 231-Pa (l,s) + 1.5 O2 (g) → Pa2O3 (o)	1.0
Pb+2 (l,s) + 0.5 O2 (g) → PbO (o)	1.0
Pd+2 (l,s) + 0.5 O2 (g) → PdO (o)	1.0
2 Pr+3 (l,s) + 1.5 O2 (g) → Pr2O3 (o)	1.0
• Sum Pu+4, 238-Pu, 239-Pu, 240-Pu, 241-Pu, and 242-Pu to Pu+4	
Pu+4 (l,s) + O2 (g) → PuO2 (o)	1.0
• Sum 226-Ra and 228-Ra to 226-Ra	
2 226-Ra (l,s) + O2 (g) → 2 RaO (o)	1.0
2 Rb+ (l,s) + 0.5 O2 (g) → Rb2O (o)	1.0
2 Rh+3 (l,s) + 1.5 O2 (g) → Rh2O3 (o)	1.0
• Sum Ru+3 and 106-Ru to Ru+3	
Ru+3 (l,s) + O2 (g) → RuO2 (o)	1.0
SO4-2 (l,s) → SO3 (o) + 0.5 O2 (g)	1.0
• Sum Sb+5 and 125-Sb to Sb+5	
2 Sb+5 (l,s) + 1.5 O2 (g) → Sb2O3 (o)	1.0
• Sum Se+6 and 79-Se to Se+6	
Se+6 (l,s) + O2 (g) → SeO2 (o)	1.0
Si+4 (l,s) + O2 (g) → SiO2 (o)	1.0

2 151-Sm (l,s) + 1.5 O2 (g) → Sm2O3 (o)	1.0
126-Sn (l,s) + O2 (g) → SnO2 (o)	1.0
• Sum Sr+2 and 90-Sr to Sr+2	
Sr+2 (l,s) + 0.5 O2 (g) → SrO (o)	1.0
2 Ta+5 (l,s) + 2.5 O2 (g) → Ta2O5 (o)	1.0
• Sum Tc+7 and 99-Tc to Tc+7	
Tc+7 (l,s) + 3.5 O2 (g) → Tc2O7 (o)	1.0
Te+6 (l,s) + O2 (g) → TeO2 (o)	1.0
• Sum Th+4, 229-Th, and 232-Th to Th+4	
Th+4 (l,s) + O2 (g) → ThO2 (o)	1.0
Ti+4 (l,s) + O2 (g) → TiO2 (o)	1.0
4 Tl+3 (l,s) + O2 (g) → 2 Tl2O (o)	1.0
• Sum U(TOTAL), 232-U, 233-U, 234-U, 235-U, 236-U, and 238-U to U(TOTAL)	
2 U(TOTAL) (l,s) + 3 O2 (g) → 2 UO3 (o)	1.0
2 V+5 (l,s) + 2.5 O2 (g) → V2O5 (o)	1.0
W+6 (l,s) + 1.5 O2 (g) → WO3 (o)	1.0
• Sum Y+3 and 90-Y to Y+3	
2 Y+3 (l,s) + 1.5 O2 (g) → Y2O3 (o)	1.0
Zn+2 (l,s) + 0.5 O2 (g) → ZnO (o)	1.0
• Sum Zr+4 and 93-Zr to Zr+4	
Zr+4 (l,s) + O2 (g) → ZrO2 (o)	1.0

A lower set volume (1,067 gallons) is applied to the HLW melters where the molten glass above the set volume is transferred to the IHLW canisters. HMP-MLTR-00001 transfers molten glass to IHLW1 while HMP-MLTR-00002 transfers molten glass to IHLW2. The IHLW canisters are 300 gallons in size. IHLW glass has a 2.66 g/cm³ density. Canister counts and glass compositions are tracked by the model. Gases from the melter are routed to a corresponding HLW Offgas Process system. HMP-MLTR-00001 transfers materials to HOP-SCB-00001 and HMP-MLTR-00002 transfers materials to HOP-SCB-00002.

Figures F-19 and F-20 provide the graphical illustration of the HMP systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the HMP.

4.8.19 HLW Melter Offgas Treatment Process (HOP) System

Vessel Tag #	Equipment Description
HOP-SCB-00001	HLW Melter 1 Submerged Bed Scrubber
HOP-SCB-00002	HLW Melter 2 Submerged Bed Scrubber
HOP-VSL-00903	HLW SBS Condensate Receiver Vessel
HOP-VSL-00904	HLW SBS Condensate Receiver Vessel

The HLW SBSs receive offgas from the HLW melters. HOP-SCB-00001 receives material from HMP-MLTR-00001 and HOP-SCB-00002 receives material from HMP-MLTR-00002. Each of the HLW SBSs are associated with a SBS Condensate Vessel. For modeling simplicity, the condensate vessels have been merged into their associated SBSs, for example, working volumes have been combined as follows:

HOP-SCB-00001/2

Minimum Volume = 1,758 + 0 gallons = 1,758 gallons
Maximum Volume = 5,808 + 3,329 gallons = 9,137 gallons
Set Volume = 8,137 gallons

Maximum Accumulation Time = 24 hours

Initially, the scrubbers are filled to their set volume with demineralized water from a chem-add. Upon arriving at the SBS, entrained liquid and solid from the melter are split to the WESP according to the split values given in Table D-20. The remaining liquid and solid materials undergo the following reactions (reactions take place in the order presented):

Reactions	Conversion (Fraction)
$\text{H}_2\text{O (g)} \rightarrow \text{H}_2\text{O (l) or H}_2\text{O (l)} \rightarrow \text{H}_2\text{O (g)}$	0.138 mole fraction at outlet
$\text{Hg (g)} \rightarrow \text{Hg+2 (l)}$	Eq. 69
$2 \text{ B+3 (s)} + 1.5 \text{ O}_2 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ H+ (l)} + 2 \text{ B+3 (l)} + 4 \text{ O-2 (l)} + 2 \text{ H}_2\text{O (l)}$	1.0
$\text{HCl (g)} \rightarrow \text{Cl- (l)} + \text{H+ (l)}$	0.7561
$\text{HF (g)} \rightarrow \text{F- (l)} + \text{H+ (l)}$	0.9825
$3 \text{ NO}_2 \text{ (g)} + \text{H}_2\text{O (l)} \rightarrow 2 \text{ NO}_3\text{- (l)} + 2 \text{ H+ (l)} + \text{NO (g)}$	0.002
$4 \text{ NO (g)} + 2 \text{ H}_2\text{O (l)} + 3 \text{ O}_2 \text{ (g)} \rightarrow 4 \text{ NO}_3\text{- (l)} + 4 \text{ H+ (l)}$	0.0548
$\text{P}_2\text{O}_5 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 0.5 \text{ PO}_4\text{-3 (l)} + 1.5 \text{ PO}_4\text{-3 (s)} + 6 \text{ H+ (l)}$	0.9451
$\text{SO}_2 \text{ (g)} + \text{H}_2\text{O (l)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{SO}_4\text{-2 (l)} + 2 \text{ H+ (l)}$	0.8534
$\text{C}_2\text{H}_3\text{N (g)} \rightarrow \text{C}_2\text{H}_3\text{N (l)}$	0.8
$\text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (g)} \rightarrow \text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (l)}$	0.8837
$129\text{-I (g)} \rightarrow 129\text{-I (l)}$	0.6875
$\text{Na+ (s)} + \text{Cl- (s)} \rightarrow \text{Na+ (l)} + \text{Cl- (l)}$	1.0 [Cl-] (s) = 0.0
$\text{Nap+ (s)} + \text{Cl- (s)} \rightarrow \text{Nap+ (l)} + \text{Cl- (l)}$	1.0 [Cl-] (s) = 0.0
$\text{Na+ (s)} + \text{F- (s)} \rightarrow \text{Na+ (l)} + \text{F- (l)}$	1.0 [F-] (s) = 0.0
$\text{Nap+ (s)} + \text{F- (s)} \rightarrow \text{Nap+ (l)} + \text{F- (l)}$	1.0 [F-] (s) = 0.0
$4 \text{ Na+ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Na+ (l)} + 4 \text{ OH- (l)}$	0.9
$4 \text{ Nap+ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Nap+ (l)} + 4 \text{ OH- (l)}$	0.9
$4 \text{ K+ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ K+ (l)} + 4 \text{ OH- (l)}$	0.95
$2 \text{ Ca+2 (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ Ca+2 (l)} + 4 \text{ OH- (l)}$	0.75
$2 \text{ Sr+2 (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ Sr+2 (l)} + 4 \text{ OH- (l)}$	0.65
$2 \text{ 90-Sr (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ 90-Sr (s)} + 4 \text{ OH- (l)}$	0.65
$4 \text{ Li+ (s)} + \text{O}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)} \rightarrow 4 \text{ Li+ (l)} + 4 \text{ OH- (l)}$	0.95
$\text{NH}_3 \text{ (g)} \rightarrow \text{NH}_3 \text{ (l)}$	0.90
$\text{NH}_3 \text{ (l)} + \text{H}_2\text{O (l)} \rightarrow \text{NH}_4\text{+ (l)} + \text{OH- (l)}$	Eq. 68
$\text{CO}_2 \text{ (g)} + \text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{CO}_3 \text{ (l)}$	0.001
$\text{H}_2\text{CO}_3 \text{ (l)} \rightarrow \text{HCO}_3\text{- (l)} + \text{H+ (l)}$	Eq. 64
$\text{HCO}_3\text{- (l)} \rightarrow \text{CO}_3\text{-2 (l)} + \text{H+ (l)}$	Eq. 65
$\text{H+ (l)} + \text{OH- (l)} \rightarrow \text{H}_2\text{O (l)}$	1.0

Conversion factor of the mercury reaction is dependent upon the mercury to chloride ratio in the HLW melter feed, for example,

$$\begin{aligned}
 \text{CF} &= 0.833 && \text{if } \text{Hg+2 (l, s)} / \text{Cl- (l, s)} \leq 0.1 \\
 &= 0.559 && \text{if } 0.1 < \text{Hg+2 (l, s)} / \text{Cl- (l, s)} \leq 0.5 \\
 &= 0.286 && \text{if } \text{Hg+2 (l, s)} / \text{Cl- (l, s)} > 0.5
 \end{aligned}
 \tag{Eq. 69}$$

The remaining gaseous mercury continues on as “Hg” to HOP-WESP-00001/2. The SBS split values for Hg+2 (l, s) are set to zero.

The production of $\text{NH}_3 \text{ (g)}$ from the melter is dependent upon the pH value at the SBS at the end of the above reactions. Initially, the multiplier M of the stoichiometric coefficients for Eq. 54 and Eq. 55 is set to 1.0. The M value is increased if pH at the SBS is below 7.0 and is decreased if pH is above 7.0. This provides the means for achieving a pH 7.0 at the SBS by adjusting the production of NH_3 at the melter.

Due to the delay effect of the above modeling approach, the following chemical reactions are used to provide further adjustment.

if $\text{pH} < 7.0$ then

$10 \text{ H}^+ (\text{l}) + \text{NO}_3^- (\text{l}) \rightarrow \text{NH}_4^+ (\text{l}) + 3 \text{ H}_2\text{O} (\text{l})$	until H^+ or NO_3^- are consumed
$8 \text{ H}^+ (\text{l}) + \text{NO}_2 (\text{l}) \rightarrow \text{NH}_4^+ (\text{l}) + 2 \text{ H}_2\text{O} (\text{l})$	until H^+ or NO_2^- are consumed

if $\text{pH} > 7.0$ then

$\text{NH}_4^+ (\text{l}) + 2 \text{ H}_2\text{O} \rightarrow \text{NO}_2^- (\text{l}) + 8 \text{ H}^+$	until $\text{pH} = 7.0$ or NH_4^+ is consumed
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It shall be noted that the pH control measures above are a modeling technique to approximate the experimental data, which indicated a near pH neutral environment in the SBS.

Water is condensed or evaporated based on the mole fraction of H_2O in the offgas stream exiting the HLW SBS. The goal is to have a mole fraction of 0.123 H_2O (g) in the offgas stream. When feed is unavailable to the melter, water vapor entering the SBS is dramatically reduced causing the water in SBS to evaporate. Under this circumstance, the SBS water chem-add will be utilized to replenish the scrubber column. Tritium (3-H) and peroxide (H_2O_2) follow water, e.g., splits are dynamically calculated in every time step in accordance with water condensation/evaporation.

The SBS volume is recalculated after the reactions. HOP-SCB-00001 transfers the offgas to HOP-WESP-00001 while HOP-SCB-00002 to HOP-WESP-00002. A SBS will accumulate condensate until either the set volume or the 24-hour maximum accumulation time has been reached. The SBS discharges the condensate to RLD-VSL-00007 if the vessel is ready to receive, or continue to accumulate while waiting for RLD-VSL-00007 to become ready. A 1000-gallon headspace (e.g., $V_{\text{max}} - V_{\text{set}}$) is reserved for each SBS to allow buffer for continuous operations.

Vessel Tag #	Equipment Description
HOP-WESP-00001	HLW Wet Electrostatic Precipitator
HOP-WESP-00002	HLW Wet Electrostatic Precipitator

Gases that exit each HLW SBS are routed to a corresponding HLW WESP. HOP-WESP-00001 receives the offgas from HOP-SCB-00001 and HOP-WESP-00002 receives the offgas from HOP-SCB-00002. Upon arriving at the WESP, entrained liquid and solid from the SBS are split to the HEME according to the split values given in Table D-21. Demin water is initially pumped to the WESP through a chem-add at a rate of 0.42 gpm which is determined base on a 3 MTG/day IHLW glass production. The demin water rate is proportioned to the melter production rate when HLW ramps up to 3.75 MTG/day in 2023. In addition, air is added to the WESP to maintain the electrodes are dry and clean. For modeling purpose, this air is combined with the HLW Vessel Vent air stream. The total air injected is 131.5 cfm at 95 °F and 14.7 psi.

The HLW WESP then performs the following reactions:

Reactions	Conversion (Fraction)
$\text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_2\text{O} (\text{g})$ or $\text{H}_2\text{O} (\text{g}) \rightarrow \text{H}_2\text{O} (\text{l})$	0.162 mole fraction at outlet
$\text{HCl} (\text{g}) \rightarrow \text{Cl}^- (\text{l}) + \text{H}^+ (\text{l})$	0.8947

Reactions	Conversion (Fraction)
$\text{HF (g)} \rightarrow \text{F}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.5000
$129\text{-I (g)} \rightarrow 129\text{-I (l)}$	0.4118
$\text{SO}_2 \text{ (g)} + \text{H}_2\text{O (l)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{SO}_4\text{-2 (l)} + 2 \text{ H}^+ \text{ (l)}$	0.1667
$\text{P}_2\text{O}_5 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 6 \text{ H}^+ \text{ (l)} + 0.5 \text{ PO}_4\text{-3 (l)} + 1.5 \text{ PO}_4\text{-3 (s)}$	0.8
$2 \text{ NO (g)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ H}_2\text{O (l)} + 4 \text{ H}^+ \text{ (l)} + 2 \text{ NO}_3^- \text{ (l)}$	0.01
$\text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (g)} \rightarrow \text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (l)}$	0.0909
$2\text{B}+3 \text{ (s)} + 1.5 \text{ O}_2 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ H}^+ \text{ (l)} + 2 \text{ B}+3 \text{ (l)} + 4 \text{ O}^{2-} \text{ (l)} + 2 \text{ H}_2\text{O (l)}$	1.0
$\text{H}^+ \text{ (l)} + \text{OH}^- \text{ (l)} \rightarrow \text{H}_2\text{O (l)}$	1.0

H₂O is evaporated or condensed based on the mole fraction of H₂O in the offgas stream exiting the HLW WESP. The goal is to have a mole fraction of 0.162 H₂O (g) in the offgas stream. The gases exit the WESP and pass to the corresponding HLW HEME while the remaining flows to the corresponding HLW SBS Condensate Vessel. HOP-WESP-00001 transfers offgas to HOP-HEME-00001 and transfers condensate to HOP-VSL-00903. HOP-WESP-00002 transfers offgas to HOP-HEME-00002 and transfers condensate to HOP-VSL-00904.

Vessel Tag #	Equipment Description
HOP-HEME-00001	High Efficiency Mist Eliminator
HOP-HEME-00002	High Efficiency Mist Eliminator

Gases that leave the HLW WESP are combined with an air stream that models the HLW Vessel Vent and is routed to the corresponding HLW HEME. HOP-HEME-00001 receives offgas from HOP-WESP-00001 and HOP-HEME-00002 receives offgas from HOP-WESP-00002. Upon arriving at the HEME, entrained liquid and solid are split to the HLW HEPA according to the split values given in Table D-22. Water is transferred to each HLW HEME through a chem-add at a rate of 0.15 gpm per 3.0 MTG/day melter operations initially. The flowrate is proportioned to the melter production rate during the ramp up in 2023. The HEME then performs the following reactions:

Reactions	Conversion (Fraction)
$\text{H}_2\text{O (l)} \rightarrow \text{H}_2\text{O (g)} \text{ or } \text{H}_2\text{O (g)} \rightarrow \text{H}_2\text{O (l)}$	0.118 mole fraction at outlet
$\text{Hg (g)} \rightarrow \text{Hg}^{+2} \text{ (l)}$	Eq. 70
$\text{HCl (g)} \rightarrow \text{Cl}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.8684
$\text{HF (g)} \rightarrow \text{F}^- \text{ (l)} + \text{H}^+ \text{ (l)}$	0.8684
$129\text{-I (g)} \rightarrow 129\text{-I (l)}$	0.0
$\text{SO}_2 \text{ (g)} + \text{H}_2\text{O (l)} + 0.5 \text{ O}_2 \text{ (g)} \rightarrow \text{SO}_4\text{-2 (l)} + 2 \text{ H}^+ \text{ (l)}$	0.9845
$\text{P}_2\text{O}_5 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 6 \text{ H}^+ \text{ (l)} + 0.5 \text{ PO}_4\text{-3 (l)} + 1.5 \text{ PO}_4\text{-3 (s)}$	0.99
$\text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (g)} \rightarrow \text{C}_{12}\text{H}_4\text{Cl}_6 \text{ (l)}$	0.997959
$2\text{B}+3 \text{ (s)} + 1.5 \text{ O}_2 \text{ (g)} + 3 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ H}^+ \text{ (l)} + 2 \text{ B}+3 \text{ (l)} + 4 \text{ O}^{2-} \text{ (l)} + 2 \text{ H}_2\text{O (l)}$	1.0
$\text{H}^+ \text{ (l)} + \text{OH}^- \text{ (l)} \rightarrow \text{H}_2\text{O (l)}$	1.0

Conversion factor of the mercury reaction is dependent upon the mercury to chloride ratio in the HLW melter feed, for example,

$$\begin{aligned}
 \text{CF} &= 0.714 && \text{if } \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} \leq 0.1 && (\text{Eq. 70}) \\
 &= 0.357 && \text{if } 0.1 < \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} \leq 0.5 \\
 &= 0.0 && \text{if } \text{Hg}^{+2} \text{ (l, s)} / \text{Cl}^- \text{ (l, s)} > 0.5
 \end{aligned}$$

The remaining gaseous mercury continues on as “Hg” to the downstream HOP equipment. The HEME split values for Hg+2 (l, s) are set to zero.

H₂O is condensed or evaporated based on the mole fraction of H₂O in the offgas stream exiting the HLW HEME. The goal is to have a mole fraction of 0.118 H₂O (g) in the offgas stream. The remaining material is captured based on splits shown in Table D-22 and transferred to the SBS Condensate Vessel. The remaining gases exit the HEME and pass to the corresponding HLW HEPA. HOP-HEME-00001 transfers offgas to HOP-HEPA-00001-2-A/B and transfers condensate to HOP-VSL-00903. HOP-HEME-00002 transfers offgas to HOP-HEPA-00007-8-A/B and transfers condensate to HOP-VSL-00904.

Vessel Tag #	Equipment Description
HOP-HEPA-00001-2-A/B	HLW High Efficiency Particular Air Filter
HOP-HEPA-00007-8-A/B	HLW High Efficiency Particular Air Filter

A large percentage of the entrained liquid and solid components entering the HLW carbon absorbers is captured. Large percentages of the gas components are also removed. The offgas leaving the HEPA is routed to the downstream carbon absorber. Percent removals by the HEPAs are shown in Table D-23.

Vessel Tag #	Equipment Description
HOP-ADBR-00001A/B	HLW Carbon Absorber
HOP-ADBR-00002A/B	HLW Carbon Absorber

The HLW Carbon Absorber captures 99.9% of mercury from the entrained liquid and solid. It also removes 90% of the PCB from the gas stream. The offgas leaving the absorber is routed to the downstream Silver Mordenite Absorption Column. Percent removal by the carbon absorber is shown in Table D-24.

Vessel Tag #	Equipment Description
HOP-ABS-00002	Silver Mordenite Absorption Column
HOP-ABS-00003	Silver Mordenite Absorption Column

Gases enter the Silver Mordenite Absorption Columns from the corresponding HLW carbon absorbers and material is captured based on splits shown in Table D-25. Up to 99.9% of the 129-I, HCl, and HF gases are removed by the Silver Mordenite Absorption Column. The remaining gases are routed to the HLW NO_x Scrubbers.

Vessel Tag #	Equipment Description
HOP-SCR-00001	HLW NO _x Scrubber
HOP-SCR-00002	HLW NO _x Scrubber

Gases leaving the HLW Silver Mordenite Absorption Columns are routed to the corresponding HLW NO_x Scrubber. HOP-SCR-00001 receives offgas from HOP-ADBR-00001A/B and HOP-SCR-00002 receives offgas from HOP-ADBR-00002A/B. The primary purpose of the HLW NO_x Scrubber is to remove NO and NO₂ from the offgas. Pure anhydrous ammonia gas and dilution air are added through chem-adds based on the amount of NO, NO₂, and NH₃ entering the HLW NO_x Scrubber, and a 10 parts per million by volume (ppmv) NH₃ concentration in the outlet stream. After the NH₃ has entered, the following reactions occur:

Reactions	Conversion (Fraction)
$\text{NH}_3 (\text{l}) \rightarrow \text{NH}_3 (\text{g})$	1.0
$4 \text{ NO} (\text{g}) + 4 \text{ NH}_3 (\text{g}) + \text{O}_2 (\text{g}) \rightarrow 4 \text{ N}_2 (\text{g}) + 6 \text{ H}_2\text{O} (\text{g})$	0.95
$2 \text{ NO}_2 (\text{g}) + 4 \text{ NH}_3 (\text{g}) + \text{O}_2 (\text{g}) \rightarrow 3 \text{ N}_2 (\text{g}) + 6 \text{ H}_2\text{O} (\text{g})$	0.95
$\text{SO}_2 (\text{g}) + 0.5 \text{ O}_2 (\text{g}) \rightarrow \text{SO}_3 (\text{g})$	0.95
$\text{C}_2\text{H}_3\text{N} (\text{l,g}) + 3.75 \text{ O}_2 (\text{g}) \rightarrow 2 \text{ CO}_2 + 1.5 \text{ H}_2\text{O} (\text{g}) + \text{NO}_2 (\text{g})$	0.757
$\text{C}_{12}\text{H}_4\text{Cl}_6 (\text{l,g}) + 11.5 \text{ O}_2 (\text{g}) + \text{H}_2\text{O} (\text{g}) \rightarrow 12 \text{ CO}_2 (\text{g}) + 6 \text{ HCl} (\text{g})$	0.95

The HLW NO_x Scrubber then captures components based on splits shown in Table D-26. The HLW NO_x Scrubbers are the final units in HOP before entering the stack. The remaining gases exit out of the HLW NO_x Scrubbers and through HLW Offgas Stack into the atmosphere.

Vessel Tag #	Equipment Description
PJV-HEPA-00004-5	PJV High Efficiency Particular Air Filter

The PJV HEPA receives Pulse Jet Ventilation air from HOP-SCB-00001/2 and RLD-VSL-00007. Entrained liquid and solid are removed in accordance with splits shown in Table D-27. Currently, the G2 model simulates dynamic air usage for clean air only (refer to Appendix G for flow rates). Air exiting the PJV HEPA is routed to the HLW PJV Stack.

Figures F-19 and F-20 provide the graphical illustration of the HOP systems where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the HOP.

4.8.20 HLW Canister Decontamination Handling (HDH) System

Vessel Tag #	Equipment Description
HDH-VSL-00001	Canister Rinse Bogie Decon Vessel
HDH-VSL-00002	Canister Decontamination Vessel
HDH-VSL-00004	Canister Decontamination Vessel
HDH-VSL-00003	Waste Neutralization Vessel

The sequence of HLW canister decontamination is described as follows:

- 1) The bogie vessel (HDH-VSL-00001) waits until the HLW canister cooling rack has one or more canisters (the rack can hold up to 24 canisters). A canister must wait 24 hours for cooling and welding before it can be decontaminated.
- 2) A canister is moved to the bogie and waits 26 minutes.
- 3) The canister is rinsed with 180-gallon water at 90 gpm; the rinse water is drained to the waste neutralization vessel (HDH-VSL-00003) at 80 gpm concurrently. Volume changes in the bogie vessel will not be shown due to the resolution of time interval.
- 4) The canister is dried for 29 minutes.
- 5) The canister is rinsed a second time with 180-gallon water at 90 gpm, the rinse water is drained to HDH-VSL-00003 at 80 gpm concurrently. Volume changes in the bogie vessel will not be shown.
- 6) The canister is dried for 29 minutes.
- 7) The dry canister is moved to a decontamination vessel (HDH-VSL-00002 or HDH-VSL-00004). The turnaround time for the bogie vessel to become available for the next canister wash is 10 minutes

from the end of drying, the time for the decontamination vessel to start decon is 62 minutes from the end of drying. HDH-VSL-00002 and HDH-VSL-00004 are used in an alternating fashion.

- 8) HDH-VSL-00002 or HDH-VSL-00004 receives 20 gallons of cerium nitrate [0.5M Ce(NO₃)₃] at 3.2 gpm and 194 gallons of nitric acid (1M HNO₃) at 32 gpm.
- 9) HDH-VSL-00003 receives 122 gallons of steam condensate (1,020 lbs) at 0.27 gpm.
- 10) HDH-VSL-00002 or HDH-VSL-00004 waits 540 minutes (90 minutes heating, 360 minutes maintaining, 90 minutes cooling).
- 11) Decon solution in HDH-VSL-00002 or HDH-VSL-00004 is drained to HDH-VSL-00003 at 48 gpm.
- 12) Add 5.6 gallons of steam condensate to HDH-VSL-00003 at 1 gpm.
- 13) HDH-VSL-00002 or HDH-00004 waits 28 minutes.
- 14) HDH-VSL-00002 or HDH-00004 receives 201 gallons of nitric acid (1M HNO₃) at 32 gpm.
- 15) Nitric acid in HDH-VSL-00002 or HDH-00004 is drained to HDH-VSL-00003 at 48 gpm.
- 16) Add 5.6 gallons of steam condensate to HDH-VSL-00003 at 1 gpm.
- 17) HDH-VSL-00002 or HDH-VSL-00004 waits 21 minutes.
- 18) HDH-VSL-00002 or HDH-VSL-00004 receives 200 gallons of demin water at 33 gpm.
- 19) Demin water is drained to HDH-VSL-00003 at 48 gpm.
- 20) HDH-VSL-00002 or HDH-VSL-00004 waits 31 minutes (drying).
- 21) Add 5.6 gallons of steam condensate to HDH-VSL-00003 at 1 gpm.
- 22) HDH-VSL-00003 receives 0.5 gallons of hydrogen peroxide (1M H₂O₂) at 0.033 gpm.
- 23) HDH-VSL-00003 receives 83 gallons of caustic (5M NaOH) at 20.75 gpm.
- 24) The canister is moved to the HLW Canister Decon Swabbing Station and waits 235 minutes.

Repeat Steps 1 through 24 for a second HLW canister. Discharge HDH-VSL-00003 to RLD-VSL-00007 after two canisters have been decontaminated. If the canisters on the cooling rack reach the capacity limit, the HLW melter feed pumps will be shut down temporarily.

4.8.21 Plant Wash and Disposal (PWD) System

Vessel Tag #	Equipment Description
PWD-VSL-00015	Acidic/Alkaline Effluent Vessel
PWD-VSL-00016	Acidic/Alkaline Effluent Vessel

PWD-VSL-00015 and PWD-VSL-00016 operate in alternate mode and receive material from the following vessels:

Vessel Tag #	Equipment Description
UFP-VSL-00002A	Ultrafiltration Feed Vessel
UFP-VSL-00002B	Ultrafiltration Feed Vessel
CXP-IXC-00001	Cesium Ion Exchange Column
CXP-IXC-00002	Cesium Ion Exchange Column
CXP-IXC-00003	Cesium Ion Exchange Column

CXP-IXC-00004	Cesium Ion Exchange Column
CNP-DISTC-00001	Cesium Evaporator Nitric Acid Rectifier

Each vessel can only receive material from one source at a time. However, both vessels can be receiving material at the same time if receiving from different sources. If both vessels are available at the time of request, the vessel that is the fullest will be selected. PWD-VSL-00015 and PWD-VSL-00016 will receive until the set volume (82,148 gallons) is reached. A 5,000-gallon headspace is reversed in each vessel for potential pH adjustment operations. If the pH is less than 12.0, a calculated volume of 19M NaOH is added through a chem-add to the vessel until the pH reaches 12.0. The vessel then becomes available to send material to one of the two Waste Feed Evaporator Feed Vessels (FEP-VSL-00017A or FEP-VSL-00017B), depending on their availability.

Vessel Tag #	Equipment Description
PWD-VSL-00033	Ultimate Overflow Vessel

The Ultimate Overflow Vessel receives line flushes and drains from pretreatment and ultrafiltration recirculation loop flush. It also receives inhibited water from post-transfer line flushes from the Tank Farm. A contingent volume is set between the lower set point (10,386 gallons) and the upper set point (14,386 gallons). The vessel can only receive when its volume is below the lower set point. The vessel can receive and discharge when its volume is within the contingency zone. PWD-VSL-00033 can only be discharged when its volume is above the upper set point. When the vessel has met its discharge conditions, it empties its contents into PWD-VSL-00044.

Vessel Tag #	Equipment Description
PWD-VSL-00043	HLW Effluent Transfer Vessel

PWD-VSL-00043 receives neutralized HLW recycle from RLD-VSL-00007, demister solution from PJV-VSL-00001, and inhibited water for post-transfer line flushes from the Tank Farm. A contingent volume is set between the lower set point (10,301 gallons) and the upper set point (14,301 gallons). The vessel can only receive when its volume is below the lower set point. The vessel can receive and discharge when its volume is within the contingency zone. PWD-VSL-00033 can only be discharged when its volume is above the upper set point. When the vessel has met its discharge conditions, it empties its contents into PWD-VSL-00044.

Vessel Tag #	Equipment Description
PWD-VSL-00044	Plant Wash Vessel

The Plant Wash Vessel receives material from PWD-VSL-00033, PWD-VSL-00043, PVP-SCB-00002, and PVP-VSL-00001. When the vessel has reached its setpoint level, the vessel performs the following reactions:

Reaction	Conversion (Fraction)
$\text{H}_2\text{CO}_3 (\text{l}) \rightarrow \text{CO}_3^{2-} (\text{l}) + 2 \text{H}^+ (\text{l})$	1.0
$\text{HCO}_3^- (\text{l}) \rightarrow \text{CO}_3^{2-} (\text{l}) + \text{H}^+ (\text{l})$	1.0
$\text{NH}_4^+ (\text{l}) \rightarrow \text{NH}_3 (\text{l}) + \text{H}^+ (\text{l})$	1.0
$\text{Hg}^{+2} (\text{l}) + 2\text{OH}^- (\text{l}) \rightarrow \text{Hg}^{+2} (\text{s}) + \text{O}^{2-} (\text{s}) + \text{H}_2\text{O}(\text{Bound}) (\text{s})$	1.0
$\text{H}^+ (\text{l}) + \text{OH}^- (\text{l}) \rightarrow \text{H}_2\text{O} (\text{l})$	1.0

PWD-VSL-00044 will receive until the set volume (68,644 gallons) is reached. A 5,000-gallon headspace is reversed in the vessel for potential pH adjustment operation. If the pH is less than 12.0, a calculated volume of 19M NaOH is added through a chem-add to the vessel until the pH reaches 12.0. The vessel then becomes available to send material to one of the two Waste Feed Evaporator Feed Vessels (FEP-VSL-00017A or FEP-VSL-00017B), depending on their availability.

Figure F-7 provides a graphical illustration of the PWD system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the PWD.

4.8.22 Glass Formers Reagent (GFR) System

Glass formers are minerals that are added to waste batches that, when melted, produce glass. Each batch of waste is evaluated based on composition and a recipe of glass formers is generated that will produce an optimized volume of glass in the melters, with the appropriate waste loadings. The names and chemical formulas of the glass formers are shown in Table 16.

Table 16 Glass Former Minerals

Names	Chemical Formulas
Borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
Boric Acid	H_3BO_3
Iron Oxide	Fe_2O_3
Kyanite	Al_2SiO_5
Lithium Carbonate	Li_2CO_3
Olivine	$\text{Mg}_2\text{SiO}_4\text{Fe}_2\text{SiO}_4$
Rutile	TiO_2
Silica	SiO_2
Soda Ash	Na_2CO_3
Sugar	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$
Wollastonite	CaSiO_3
Zinc Oxide	ZnO
Zircon Sand	ZrSiO_4

Glass former quantities in the oxide form are calculated using the LAW and HLW glass models discussed in Sections 4.8.13 and 4.8.17, respectively, and in the *BARD*. However, minerals equivalent to the calculated oxide glass formers are actually transferred to the MFPVs. These minerals contain the glass former oxides, impurities, and water moisture. Table 17 shows the makeup of the mineral glass formers.

For most glass formers, the moisture contents are partitioned into detachable water and non-detachable water in a 50:50 ratio. The H₂O(Bound) in Table 16 has combined the non-detachable portion of moisture with H₂O(Bound) attached to the minerals. The H₂O(Bound) acts like a solid and will contribute to weight percent solid calculations and solid volume calculations. Upon arriving at an MFPV, the detachable portion of moisture will be removed from the oxide array and added to the liquid array that contributes to the rheology water calculations and liquid volume calculations. The H₂O(Bound) that remains in the oxide array is vaporized in the melter.

Table 17 Makeup of Mineral Glass Formers

Oxide Array	Borax	Boric Acid	Iron Oxide	Kyanite	Lithium Carbonate	Olivine	Rutile	Silica	Soda Ash	Sugar	Wollastonite	Zinc Oxide	Zircon Sand
Ac ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Ag ₂ O	0	0	0	0	0	0	0	0	0	0	0	0	0
Al ₂ O ₃	0	0	15,000	570,000	0	1,900	5,000	1,350	0	0	2,000	0	2,500
Am ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
As ₂ O ₅	0	0	0	0	0	0	0	0	0	0	0	0	0
B ₂ O ₃	375,000	565,300	0	0	0	0	0	0	0	0	0	0	0
BaO	0	0	0	0	0	0	0	0	0	0	0	0	0
BeO	0	0	0	0	0	0	0	0	0	0	0	0	0
Bi ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
CaO	0	0	400	400	14	200	0	80	49	0	475,000	0	0
CdO	0	0	0	0	0	0	0	0	0	0	0	50	0
CeO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl	700	18	0	0	100	0	0	0	182	0	0	0	0
Cm ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Co ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr ₂ O ₃	0	0	0	0	0	1,300	1,600	0	0	0	0	0	0
Cs ₂ O	0	0	0	0	0	0	0	0	0	0	0	0	0
CuO	0	0	0	0	0	0	0	0	0	0	0	0	0
Dy ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Eu ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe ₂ O ₃	43	9	965,373	7,100	400	76,800	7,000	160	3	0	4,000	10	750
HgO	0	0	0	0	0	0	0	0	0	0	0	0	0
K ₂ O	0	0	0	700	0	100	0	170	0	0	0	0	0
La ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Li ₂ O	0	0	0	0	402,000	0	0	0	0	0	0	0	0

Oxide Array	Borax	Boric Acid	Iron Oxide	Kyanite	Lithium Carbonate	Olivine	Rutile	Silica	Soda Ash	Sugar	Wollastonite	Zinc Oxide	Zircon Sand
MgO	0	0	1,000	400	995	480,100	0	80	41	0	1,000	0	0
MnO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
MoO ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Na ₂ O	0	0	0	0	0	0	0	0	0	0	0	0	0
Nb ₂ O ₅	0	0	0	0	0	0	4,000	0	0	0	0	0	0
Nd ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
NiO	0	0	0	0	0	3,700	0	0	0	0	0	0	0
NpO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
P ₂ O ₅	0	0	2,635	0	0	0	458	0	0	0	0	0	0
PbO	0	0	0	0	0	0	0	0	0	0	0	10	0
PdO	0	0	0	0	0	0	0	0	0	0	0	0	0
Pr ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
PuO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
Rb ₂ O	0	0	0	0	0	0	0	0	0	0	0	0	0
Re ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Rh ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Ru ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
SeO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
SiO ₂	0	0	13,500	410,500	0	435,700	22,000	998,060	0	0	516,687	0	340,250
Sm ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
SnO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
SO ₃	500	292	799	0	33	0	250	0	56	0	0	0	0
SrO	0	0	0	0	0	0	0	0	0	0	0	0	0
Ta ₂ O ₅	0	0	0	0	0	0	0	0	0	0	0	0	0
Tc ₂ O ₇	0	0	0	0	0	0	0	0	0	0	0	0	0
TeO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0
ThO ₂	0	0	0	0	0	0	0	0	0	0	0	0	450

Oxide Array	Borax	Boric Acid	Iron Oxide	Kyanite	Lithium Carbonate	Olivine	Rutile	Silica	Soda Ash	Sugar	Wollastonite	Zinc Oxide	Zircon Sand
TiO ₂	0	0	0	10,500	0	0	936,192	80	0	0	200	0	1,050
Tl ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
U ₃ O ₈	0	0	0	0	0	0	0	0	0	0	0	0	0
V ₂ O ₅	0	0	0	0	0	0	4,500	0	0	0	0	0	0
WO ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
Y ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
ZnO	0	0	0	0	0	0	0	0	0	0	0	999,730	0
ZrO ₂	0	0	0	0	0	0	19,000	0	0	0	0	0	589,500
CO ₂	0	0	0	0	596,454	0	0	0	414,300	0	0	0	0
H ₂ O(b)	486,757	464,382	30,000	30,000	30,000	30,000	30,000	30,000	30,200	30,000	30,000	30,000	30,000
H ₂ O	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
HfO ₂	0	0	0	0	0	0	0	0	0	0	0	0	65,500
Mnp ₂ O ₃	0	0	1,293	0	0	0	0	0	0	0	1,113	0	0
Nap ₂ O	167,000	0	0	400	4	200	0	20	585,169	0	0	200	0
129-I	0	0	0	0	0	0	0	0	0	0	0	0	0
Pa ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0
RaO	0	0	0	0	0	0	0	0	0	0	0	0	0
C12H22O11	0	0	0	0	0	0	0	0	0	1,000,000	0	0	0
Ox5	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ⁽¹⁾	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000	1,060,000

Note:

⁽¹⁾ Unit is in parts per million (ppm) excluding the detachable and non-detachable moisture.

The glass former reagent system modeled includes mineral stockpiles, glass former trucks, storage silos, weigh hoppers, transporters, blending silos, mixers, and dusting water as shown in Figure F-23. A glass former equipment class is created with attributes commonly used for logical operations and mass balance calculations. A number of sub-classes are also created to accommodate the required equipment. The equipment class hierarchy is illustrated as follows (see Figure 1 for a complete WTP equipment class hierarchy):

- Glass Former Equipment
 - Mineral Chem. Add
 - Glass Former Truck
 - Silo
 - Transporter
 - Glass Former Mixer

Mineral Chem. Adds are used to represent the glass former stockpiles shown in Table 18 where the names and bulk densities of the minerals are specified. It is assumed that glass former minerals are available in unlimited quantities at any time as needed.

Table 18 Names and Bulk Densities of Glass Former Stockpiles

Stockpile Name	Bulk Density (lbs/ft³)
Silica	49.6
Wollastonite	46.4
Kyanite	56.1
Boric Acid	54.6
Sugar	52.6
Lithium Carbonate	53.1
Zinc Oxide	33.8
Soda Ash	64.2
Borax	48.0
Olivine	89.3
Rutile	91.0
Zircon Sand	96.0
Iron Oxide	88.9

Trucks are used to transport glass formers from stockpiles to storage silos. A convoy of trucks can be used for loading and hauling but only two can be unloading at the same time. It is outside the scope of this model to simulate the loading and hauling of the glass formers from the stockpiles and therefore it is assumed that a truckload of minerals is available at the truck lane entrance for unloading at any time. Because only two trucks can be unloading at the same time, a truck lane is dedicated for Systems 100, 200, and 500 while another truck lane is dedicated for Systems 300 and 400 (see Figure F-23 for details).

After a delivery order is received, a truck with the requested minerals arrives at the truck lane entrance; moves to the requesting silo; docks to the silo's truck unload line; and starts unloading. These steps are assumed to take 30-minutes. Then the mass is transferred to the silo from the truck at a rate of 500 lbs/min. A truck has a fixed capacity of 40,000 lbs although its holding volume varies depending on the bulk density of minerals. The truck undocks from the silo and leaves after it is completely emptied. These steps are assumed to take 30-minutes. The next truck can enter the truck lane after the previous one exits.

Some attributes of the truck class are shown in Table 19 where descriptions for these attributes are also provided.

Table 19 Attributes of the Truck Class

Attributes	Description
Trip No.	Keeps track of the total number of trips.
Mineral Type	Varies, is used in combination with trip no. so that glass former purchasing orders vs. time information can be collected.
Capacity (lbs)	40,000 lbs per load, volume (ft ³) = capacity / bulk density
Current Weight (lbs)	Equals to (capacity – flow rate × time step) ≥ 0.0
Flow Rate (lbs/min)	500
Solid Density (lbs/ft ³)	Varies depending on mineral types

Storage silos are used to receive, store, and deliver glass formers. The thirteen storage silos are grouped in five systems. Silos of the same system share a weigh hopper and a transporter. A silo will be restocked once more than a truckload of minerals (40,000 lbs) has been consumed. Silos will be restocked in the order in which they are requested. If requests are received from more than one silo at the same time, priority is given to the one that has a lower percent of remaining volume (emptier). A silo can receive and deliver glass formers at the same time. All the storage silos are stocked initially before the plant startup. Table 20 shows the attributes of the silo class and Table 21 summarizes the attribute values of the storage silos.

Table 20 Attributes of the Silo Class

Attributes	Description
Minimum Volume (ft ³)	Heel volume, equals to 0.0
Current Solid Volume (ft ³)	Remaining volume in silo
Set Volume (ft ³)	Equals to (max vol. – 40,000 / solid density), rounded lower to prevent silo overfill. Triggers a purchasing order
Maximum Volume (ft ³)	Equals to capacity
Flow Rate (ft ³ /min)	Varies depending on silos
Solid Density (lbs/ft ³)	Varies depending on mineral types

Table 21 Attribute Values of the Storage Silos

Storage Silo	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density (lbs/ft ³)	Set Volume (ft ³)
GFR-TK-00001	Silica	8,500	5.7	49.6	7,650
GFR-TK-00010	Wollastonite	3,000	9	46.4	2,100
GFR-TK-00008	Kyanite	2,175	5.88	56.1	1,450
GFR-TK-00007	Boric Acid	3,000	10.2	54.6	2,250
GFR-TK-00011	Sugar	1,800	7.2	52.6	1,000
GFR-TK-00006	Lithium Carbonate	2,500	6	53.1	1,700
GFR-TK-00002	Zinc Oxide	2,500	2.88	33.8	1,300
GFR-TK-00012	Soda Ash	1,500	7.62	64.2	850
GFR-TK-00028	Borax	2,150	9.18	48.0	1,300
GFR-TK-00009	Olivine	1,000	3	89.3	550
GFR-TK-00003	Rutile	1,000	0.78	91.0	550
GFR-TK-00005	Zircon Sand	1,000	4.68	96.0	550
GFR-TK-00004	Iron Oxide	1,000	0.72	88.9	550

A glass former recipe must be determined for each batch of LAW and HLW wastes to the Melter Feed Preparation Vessels. Glass former recipe determinations are discussed in Section 4.8.13 for LAW and Section 4.8.17 for HLW. After a MFPV receives an entire waste batch, the vessel must wait if the glass formers have not already been prepared.

Glass former requests are processed in the order they are received as the storage silos, weigh hoppers, transporters, and blending silos are shared. However, higher priority will be given to the HLW facilities if requests are received at the same time.

Systems 100 through 500 will operate in parallel, for example, the five weigh hoppers and their associated transporters can receive feeds from storage silos and discharge to the blending silo at the same time. Because they share the same weigh hopper and transporter, silos of the same system (i.e., Systems 200, 300, 400, and 500) will operate in sequence in the order from left to right. Multiple batches might be needed if the required glass former quantity exceeds the capacity of the weigh hopper/transporter. If a weigh hopper is partially filled with a glass former, it will continue to be filled with other required glass formers. Density of the mixture is calculated using the equation below:

$$\rho_m = (V_1 \times \rho_1 + V_2 \times \rho_2 + \dots V_i \times \rho_i) / (V_1 + V_2 + \dots + V_i) \quad \text{Eq. (71)}$$

Where:

V = Volume of a glass former mineral (ft³);
 ρ = Density of a glass former mineral (lbs/ft³);

Similar to the weigh hoppers, bulk density of the transporters varies depending on the mineral types and mixtures.

Weigh hoppers are derived from the silo equipment class. Transporters also share the same class attributes as silos. Attribute values of the weigh hoppers and their associated transporters are shown in Table 22 and Table 23.

Table 22 Attribute Values of the Weigh Hoppers

Weigh Hopper	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density ^(a) (lbs/ft ³)
GFR-TK-00013	System 100 Weigh Hopper	10	163.8	49.6
GFR-TK-00016	System 200 Weigh Hopper	10	129	Varies
GFR-TK-00015	System 300 Weigh Hopper	10	51.6	Varies
GFR-TK-00018	System 400 Weigh Hopper	10	136.8	Varies
GFR-TK-00014	System 500 Weigh Hopper	3	61.2	Varies

Note:

^(a) Bulk density varies as the weigh hoppers are used to handle different minerals and their mixtures.

Table 23 Attribute Values of the Transporters

Transporter	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density (lbs/ft ³)
GFR-VSL-00002	System 100 Transporter	10	2.5	49.6
GFR-VSL-00003	System 200 Transporter	10	2.9	Varies
GFR-VSL-00004	System 300 Transporter	10	2.5	Varies
GFR-VSL-00005	System 400 Transporter	10	2.5	Varies
GFR-VSL-00006	System 500 Transporter	3	0.7	Varies

Two blending silos are used to receive and blend the different minerals from the storage silos and their associated weigh hoppers and transporters. GFR-TK-00019 is dedicated for LAW glass formers while GFR-TK-00021 is dedicated for HLW glass formers. A blending silo can receive glass formers from any number of transporters simultaneously. If the volume of a glass former recipe is greater than the capacity of the blending silo, two batch transfers will be made into and out of the blending silo, the following mixer, then to the requesting MFPV. These two batches will come proportionally from the associated storage silos. Blending starts after the entire contents of the glass former recipe are received. Blending will take 15 minutes to complete.

Blending silos are derived from the silo equipment class and therefore possess the same attributes. Table 24 summarizes the attribute values of the LAW and HLW blending silos.

Table 24 Attribute Values of the Blending Silos

Blending Hopper	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density (lbs/ft ³)
GFR-TK-00019	LAW Blending Silo	470	252.7	Variable
GFR-TK-00021	HLW Blending Silo	320	205.8	Variable

Blended glass formers are delivered to the associated transporters which then transfer the contents to the designated glass former mixers. Transporter GFR-VSL-00007 is associated upstream with the LAW blending silo and downstream with the LAW glass former mixers. Transporter GFR-VSL-00008 is associated upstream with the HLW blending silo and downstream with the HLW glass former mixers. Attribute values of the LAW/HLW transporters are summarized in Table 25.

Table 25 Attribute Values of the LAW/HLW Transporters

Transporter	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density (lbs/ft ³)
GFR-VSL-00007	LAW Transporter	80	7.8	Variable
GFR-VSL-00008	HLW Transporter	80	5.3	Variable

Four glass former mixers are used to receive, mix, and deliver the finished glass former contents to the dedicated MFPVs. After the entire contents of the LAW/HLW transporters are received, dusting water is added to the mixer, i.e., 4 wt% for LAW and 5 wt% for HLW and mixed. The mixing process takes 20 minutes. Each mixer is dedicated to a MFPV, for example, GFR-TK-00022 to LFP-VSL-00003, GFR-TK-00023 to LFP-VSL-00001, GFR-TK-00025 to HFP-VSL-00005, and GFR-TK-00031 to HFP-VSL-00001, respectively. Once again, it is assumed that the glass former mixers have the capacities to hold the ingredients of any glass former recipes, and if not, the mixers will allow topping off their maximum volumes. Attribute values of the mixers are summarized in Table 26.

Table 26 Attribute Values of the LAW/HLW Glass Former Mixers

Transporter	Alternate Name	Capacity (ft ³)	Flow Rate (ft ³ /min)	Density (lbs/ft ³)
GFR-TK-00022	LFP-VSL-00003 Mixer	470	6.5	Variable
GFR-TK-00023	LFP-VSL-00001 Mixer	470	6.5	Variable
GFR-TK-00025	HFP-VSL-00005 Mixer	320	4.5	Variable
GFR-TK-00031	HFP-VSL-00001 Mixer	320	4.5	Variable

Figure F-23 provides a graphical illustration of the GFR system where connections with upstream and downstream systems are shown. Table N-1 provides the totalizer files that are used to track the process streams and material flows into and out of the GFR.

4.9 Workspace Description

The model is divided into workspaces. Each workspace can model up to two systems. Table 27 provides a list showing which systems are modeled in each workspace. Screenshots of the workspaces are shown in Appendix F.

Table 27 Workspace Description

RPP-WTP System	G2 Model Workspace	Figure No
FRP – Waste Feed Receipt Process System	Waste Feed Receipt	F-3
FEP – Waste Feed Evaporation Process System	Waste Feed Evaporation	F-4
UFP – Ultrafiltration Process System	Ultrafiltration	F-5
HLP – HLW Lag Storage and Feed Blending Process System	HLW Lag Storage and Feed Blending	F-17
CXP – Cesium Ion Exchange Process System	Cesium Ion Exchange	F-8
CNP – Cesium Nitric Acid Recovery Process System	Cesium Nitric Acid Recovery	F-10
CRP – Cesium Resin Addition Process System	Resin Dewatering Process	F-9
RDP – Spent Resin Collection and Dewatering Process System	Spent Resin Collection and Dewatering	F-9
TLP – Treated LAW Evaporation Process System	Treated LAW Evaporation and Concentrate Storage	F-11
TCP – Treated LAW Concentrate Storage Process System	Treated LAW Evaporation and Concentrate Storage	F-11
PVP – Pretreatment Vessel Vent Process System	Pretreatment Vessel Vent Process	F-6
PWD – Plant Wash and Disposal System	Plant Wash and Disposal (Recycle)/ PWD Effluent Collection	F-7
Pretreatment Process Reagent Handling System	Modeled by Chem-Adds	Throughout
LCP – LAW Concentrate Receipt Process System	LAW Melter Feed	F-12
LFP – LAW Melter Feed Process System		
LMP – LAW Melter Process System	LAW Melters	F-13
LOP – LAW Primary Offgas Process System		F-14
LVP – LAW Secondary Offgas/Vessel Vent Process System	LAW Offgas Treatment System	F-15
LAW-RLD – LAW Radioactive Liquid Waste Disposal System	RLD Process Condensate Collection/ LAW Liquid Effluent	F-16 F-24
LAW-NLD – LAW Non-Radioactive Liquid Waste Disposal System		
GFR – Glass Formers Reagent System	Glass Formers	F-23
LFH – LAW Container Finishing Handling System	Not modeled by G2 model	Not Modeled

RPP-WTP System	G2 Model Workspace	Figure No
LAW Reagent Handling Systems	Modeled by Chem-Adds	Throughout
HFP – HLW Melter Feed Process System	HLW Melter Feed and Melter	F-18
HMP – HLW Melter Process System	HLW Melter Feed and Melter	F-19 F-20
HOP – HLW Melter Offgas Treatment Process System	HLW Offgas Treatment	F-19 F-20
PJV – Pulse Jet Ventilation	Pretreatment Vessel Vent Process	F-6
HLW-RLD – HLW Radioactive Liquid Waste Disposal System HLW-NLD – HLW Non-Radioactive Liquid Waste Disposal System	RLD Process Condensate Collection/ HLW Liquid Effluent	F-22
HDH – HLW Canister Decontamination Handling System	HLW Canister Decon	F-21
HLW Reagent Handling Systems	Modeled by Chem-Adds	Throughout

An exception to the information in Table 27 is the Tank Farms HLW Batch Receipt Vessel HLP-VSL-00022 residing in the workspace Waste Feed Receipt (FRP).

5 Model Construction

The G2 model is constructed of many knowledge base files. The KBs contain objects, procedures (codes), and graphical interfaces.

5.1 Knowledge Base

G2 applications are stored in American Standard Code for Information Interchange (ASCII) files with a .kb extension. These files are referred to as KBs, and contain all the information the application needs to run. G2 applications can have a single file or many files. Elements of KBs come in several different forms in the G2 model, including the following:

- **Object** – An object is a piece of information that contains all related knowledge in one location. In object-oriented terms, an object's data is called its attributes, and an object's operations include rules, methods, and procedures (e.g., a tank object contains all the data that defines the tank and all the operations that the tank can perform).
- **Definitions** – Definitions describe the common features of objects (e.g., all the tanks have volumes, all pipes have flowrates, and all pumps have pump procedures).
- **Operations** – Operations are the codes that perform the computation using rules, methods, and procedures.
- **Graphical user interface** – GUIs enable the user to interact with the application.

A workspace is a two-dimensional area upon which objects and definitions are placed and the GUI is built. There are top-level workspaces and sub-workspaces. The user can move a workspace by dragging it to a desired place within Opened G2-Windows. The user can manipulate workspaces by using the **KB Workspace menu**, (e.g., to hide, print, lift to top, and drop to bottom). The user can single-right-click the background area with a workspace to obtain the **KB Workspace menu**. The user can use the lift to top command to make a workspace entirely visible or use the drop to bottom command to bring up a workspace which is covered by the active workspace. A workspace can be removed from G2-Window by using the hide command.

The programming code used in G2 is object oriented. G2 uses its own type of coding language, which is similar to C#. The procedures are located within each workspace. A procedure begins with a statement of its title and function. Next, the variables used within the program are listed and the operating logic or control logic of the procedure is given such as other procedures being called, if/then statements, pumping orders, and data reporting functions. The procedures are written in G2 language. G2 language is strongly object oriented and is most similar to Pascal.

5.2 Computation Environment

See *System Design for Process Modeling* (24590-WTP-PL-TE-01-008) for the modeling environment.

5.3 Inputs and Outputs

5.3.1 Input Data

Because of the object-oriented nature of the model, input data such as those discussed throughout this document are embedded as attributes of the WTP equipment objects. These primarily include tank volumes, flowrates, sample times, splits, and chem-add compositions. Chemical reactions are also programmed in the reaction procedures that are the methods of the equipment objects.

5.3.2 Output Data

Output data from the G2 model is stored using Oracle, Version 8i. MatLab is used to extract data from Oracle then convert the data to a form that can be used in Excel spreadsheets. The spreadsheets present the data in a readable fashion for the user. The data can be written at various time intervals of every 6 simulated minutes or greater. Vessel compositions are gathered through the use of a snapshot composition which captures the contents of vessels at specified events, and through totalizing data, which acts as a summation tool for storing the component mass transferred from one piece of equipment to another over a set time interval. The duration over which the totalizer information is packaged together is specified during data processing. The typical duration is set to 30 days.

The Dynamic (G2) Flowsheet Version 7.0 is designed to provide the general data output shown in Table 28.

Table 28 General Data Output

General Data Output	Description
FEP and TLP evaporator concentrate data	SpG/Na molarity vs. time plots for FEP/TLP evaporator bottoms in Joint Photographic Experts Group (JPEG) format
Final screenshot	Final states of a model run on the GUI are captured by a screenshot in Bitmap (BMP) format. Critical information on the captured GUI include WTP mission duration, IHLW canister and ILAW container counts, and volume of treated LAW sent to the Supplemental LAW Facility
Glass property files	IHLW glass heat load, ILAW glass Cs, Sr, Tc, and TRU concentrations vs. time plots (JPEG)
Heel cleaning and dilution files	Details of the heel cleaning/dilution operations in Comma Separated Value (CSV) format
HLP-VSL-00028 conditions	Volumes and wt% solids of HLP-VSL-00028 after each sampling event (CSV)
HLW glass property data	Details of the IHLW glass formulation in Text (TXT) format

General Data Output	Description
Hydrogen generation rate data	HGR vs. time plots for vessels of interest (JPEG)
LAW glass property data	Details of the ILAW glass formulation (TXT)
Leach caustic addition	Key process parameters related to caustic leach (CSV)
Mass balance diagrams	Over the mission mass balance data on the process system level. Diagrams include AFA, Al, C2O4, Cr, Cs137, total mass, total volume, Fe, H2O, Hg, I129, Na, PO4, radionuclides, Sr90, and Tc99 (XLS)
Run summary data	Key process parameters used for flowsheet performance assessment (CSV)
Snapshot composition	Instantaneous composition data at locations of interest (CSV).
Solubility data files	Oxalate, phosphate, and aluminum phase equilibrium data at Pretreatment vessels of interest (CSV)
Supertank dilution conditions	Additions of dilution water and aluminum solubility caustic to Supertank (CSV)
Tank Farm batch delivery data	Tank Farm batch waste characteristics (CSV)
Totalizer data for process streams	Cumulated mass for the liquid, solid, oxide, and gas components through every process stream in the model (CSV)
UFP2 cycle times	Key process parameters at different stages of a UFP2 cycle, such as end of solids concentration, end of caustic leach, end of recon, end of wash forward, end of wash recycle, end of solid discharge, and start of a new cycle (CSV)
UFP2 washing data	Volumes for wash forward, wash recycle, and oxidative wash (CSV)
Volume and Sodium molarity vs. time plots for key process vessels	Data output options include CSV files and JPEG images at selected time interval: 6 minutes, 30 minutes, 60 minutes, and daily.
Volume and weight percent solids vs. time plots for key process vessels	Data output options include CSV files and JPEG images at selected time interval: 6 minutes, 30 minutes, 60 minutes, and daily.
Volume history data for key process vessels	Raw data for the sodium and wt% solids plots (CSV)
Volume history plots for LAW and HLW glass	Cumulated glass output in volume and number of canisters through the melters (LAW and HLW) are provided in CSV files and JPEG images.
Chem-add utilization data	Initial and final volumes of chem-adds for the model runs are saved in CSV files.

A model run can provide data from none of the above to all of the above depending on model run scenarios. In addition to the general data output, supplemental data outputs (SDO) can also be gathered as needed.

5.4 G2 Mass Balance Calculator

The Microsoft Visual Studio 2005 software is used for the development of automation tools for pre-/post-G2 run data manipulation/processing. The Visual C# programming language is selected because of its features in providing graphical user interface, easy interaction with Excel spreadsheet, and modularization. The Visual C# application is named “G2 Mass Balance Calculator” or G2MBC for short. G2MBC consists of three modules: 1) Feed Vector Conversion, 2) Mass Balance Diagrams, and 3) Totalizer Value Extraction. The modules are developed using three Windows forms which are then merged into a Multiple Document Interface (MDI) named “G2MBC_GUI”. G2MBC_GUI provides a pull-down menu as shown in Figure 35 where each module application can be launched independently.

The automation tools are intended for limited use, e.g., only trained modelers with Visual Studio installed, therefore, executables will not be produced for wide distribution. Functional structures of the three modules are presented in Table 29 while methods for the module development are presented in Appendices I and J. All modules have been verified and validated as part of the G2 Version 7.0 release.

Figure 35 G2MBC GUI

Table 29 G2MBC Programming Structures

Module	Routines/Subroutines	Functional Descriptions
Feed Vector Conversion	main()	Specify input/output file names and directories, Input, Call subroutines, Output
	showFVCinfo()	Display module development status (Note: this feature is disabled as methods for feed vector charge balance are still maturing and conversions are performed by independent Flowsheet Engineer)
Mass Balance Diagrams	main()	Specify input/output file names and directories, Input, Call runCalculator(), Output
	runCalculator()	Call calculateEntireFlowsheetMassBalance(), Call calculateCumulativeTotalMass(), Call calculateCumulativeTotalVolume(), Call calculateCumulativeRadioactivity(), Call calculateAluminum(), Call calculateChromium(), Call calculateIron(), Call calculateSodium(), Call calculateOxalate(), Call calculateCesium(), Call calculateStrontium(), Call calculateIodine(), Call calculateTechnetium(), Call calculateMercury(), Call calculateWater(), Call calculateAFA(), Call calculatePhosphate()
	calculateEntireFlowsheetMassBalance()	Calculate mass balance for all the streams in Figure A-1 for every liquid, solid, oxide, and gas components, Call calculateOneFile() repeatedly
	calculateOneFile()	Calculate mass balance for a single totalizer file

Module	Routines/Subroutines	Functional Descriptions
	calculateCumulativeTotalMass	Calculate cumulative total mass (liq. sol., ox, and g), Post cumulative total mass on flowsheet diagrams
	calculateCumulativeTotalVolume()	Calculate cumulative total volume (liq. and sol.), Post cumulative total volume on flowsheet diagrams
	calculateCumulativeRadioactivity()	Calculate cumulative radioactivity, Post cumulative radioactivity on flowsheet diagrams
	calculateAluminum()	Calculate cumulative aluminum mass, Post cumulative aluminum mass of flowsheet diagrams
	calculateChromium()	Calculate cumulative chromium mass, Post cumulative chromium mass of flowsheet diagrams
	calculateIron()	Calculate cumulative iron mass, Post cumulative iron mass of flowsheet diagrams
	calculateSodium()	Calculate cumulative sodium mass, Post cumulative sodium mass of flowsheet diagrams
	calculateOxalate()	Calculate cumulative oxalate mass, Post cumulative oxalate mass of flowsheet diagrams
	calculateCesium()	Calculate cumulative cesium mass, Post cumulative cesium mass of flowsheet diagrams
	calculateStrontium()	Calculate cumulative strontium mass, Post cumulative strontium mass of flowsheet diagrams
	calculateIodine()	Calculate cumulative iodine mass, Post cumulative iodine mass of flowsheet diagrams
	calculateTechnetium()	Calculate cumulative technetium mass, Post cumulative technetium mass of flowsheet diagrams
	calculateMercury()	Calculate cumulative mercury mass, Post cumulative mercury mass of flowsheet diagrams
	calculateWater()	Calculate cumulative water mass, Post cumulative water mass of flowsheet diagrams
	calculateAFA()	Calculate cumulative AFA mass, Post cumulative AFA mass of flowsheet diagrams
	calculatePhosphate()	Calculate cumulative phosphate mass, Post cumulative phosphate mass of flowsheet diagrams

Module	Routines/Subroutines	Functional Descriptions
Totalizer Value Extraction	main()	Specify input/output file names and directories, Input, Call extractEntireStreamMakeup(), Output
	extractEntireStreamMakeup()	Call extractOneFile() repeatedly
	extractOneFile()	Extract monthly data for liquid and solid volumes, Calculate monthly total volume

6 References

Project Documents

24590-WTP-GPP-PT-013, Rev 7, *Lifecycle Control of Process Model.*

24590-WTP-ICD-MG-01-019, Rev 4, *ICD 19 - Interface Control Document for Waste Feed*

24590-WTP-M4C-V37T-00009, Rev. 0, *Phosphate Solubility Algorithm*

24590-WTP-MCR-PET-09-0047, Rev 1, *Incorporate HLW Glass Shell V2.0 into Dynamic Flowsheet - G2*

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24590-WTP-PL-TE-01-008, Rev 17, *System Design for Process Modeling*

24590-WTP-RPT-M-06-002, Rev 0, *Hydrogen in Piping and Ancillary Vessels - Plant Availability Assessment.*

24590-WTP-RPT-PE-11-008, Rev 0, *TPA Milestone M-062-49 - Demonstration of the WTP Design Capacity*

24590-WTP-RPT-PET-10-020, Rev 0, *2010 WTP Tank Utilization Assessment*

24590-WTP-RPT-PR-01-011, Rev 0, *Mercury Pathway and Treatment Assessment for the WTP.*

24590-WTP-RPT-PT-02-005, Rev 6, *Flowsheet Bases, Assumptions, and Requirements.*

24590-WTP-TP-PE-11-001, Rev 0, *Dynamic (G2) Flowsheet Version 7.0 Test Plan.*

24590-WTP-VV-PE-11-001, Rev 0, *Dynamic (G2) Flowsheet Version 7.0 Verification and Validation Report.*

CCN 160514, *Gibbsite Solubility Models, Supersedes CCN 137192.*

CCN 160518, *Sodium Oxalate Solubility Model for the Dynamic Flowsheet Rev 1. Supersedes CCN 15320.*

CCN 221451, *Conversion of CCN 150372 Aluminum Solubility Equations (3) to a Reversible Form*

Other Documents

DOE. 2000. DOE Contract DE-AC27-01RV14136. US Department of Energy, Richland, WA, as amended.

Appendix A

Component List

Appendix A

Component List

Component lists are used to perform material balance calculations such as storage, material flow, separation, and reaction. These include the liquid, solid, gas, and oxide components. Each list consists of a pre-defined number of constituents that can exist in the WTP equipment object.

Table A-1 Liquid/Solid Components

Liquid/Solid Components	Component Name	Molecular Weight (kg/kg-mole)	Specific Activity (Ci/gram)
106-Ru	Ruthenium-106	105.907	3.307E+03
113m-Cd	Cadmium-113	112.904	2.244E+02
125-Sb	Antimony-125	124.905	1.037E+03
126-Sn	Tin-126	125.908	1.135E-02
129-I	Iodine-129	128.905	1.765E-04
134-Cs	Cesium-134	133.907	1.292E+03
137-Cs	Cesium-137	136.907	8.678E+01
137m-Ba	Barium-137	136.906	5.380E+08
14-C	Carbon-14	14.003	4.468E+00
151-Sm	Samarium-151	150.920	2.631E+01
152-Eu	Europium-152	151.922	1.737E+02
154-Eu	Europium-154	153.923	2.702E+02
155-Eu	Europium-155	154.923	4.856E+02
226-Ra	Radium-226	226.025	9.893E-01
227-Ac	Actinium-227	227.028	7.233E+01
228-Ra	Radium-228	228.031	2.722E+02
229-Th	Thorium-229	229.032	2.139E-01
231-Pa	Protactinium-231	231.036	4.718E-02
232-Th	Thorium-232	232.038	1.100E-07
232-U	Uranium-232	232.037	2.208E+01
233-U	Uranium-233	233.040	9.638E-03
234-U	Uranium-234	234.041	6.210E-03
235-U	Uranium-235	235.044	2.160E-06
236-U	Uranium-236	236.046	6.468E-05
237-Np	Neptunium-237	237.048	7.049E-04
238-Pu	Plutonium-238	238.050	1.713E+01
238-U	Uranium-238	238.051	3.360E-07
239-Pu	Plutonium-239	239.052	6.207E-02
240-Pu	Plutonium-240	240.054	2.271E-01
241-Am	Americium-241	241.057	3.428E+00
241-Pu	Plutonium-241	241.057	1.030E+02
242-Cm	Curium-242	242.059	3.315E+03
242-Pu	Plutonium-242	242.059	3.939E-03
243-Am	Americium-243	243.061	1.996E-01
243-Cm	Curium-243	243.061	5.056E+01
244-Cm	Curium-244	244.063	8.095E+01
3-H	Tritium	3.016	9.673E+03
59-Ni	Nickel-59	58.934	7.973E-02

Liquid/Solid Components	Component Name	Molecular Weight (kg/kg-mole)	Specific Activity (Ci/gram)
60-Co	Cobalt-60	59.934	1.130E+03
63-Ni	Nickel-63	62.930	5.675E+01
79-Se	Selenium-79	78.918	6.962E-03
90-Sr	Strontium-90	89.908	1.380E+02
90-Y	Yttrium-90	89.907	5.434E+05
93-Zr	Zirconium-93	92.906	2.563E-03
93m-Nb	Niobium-93	92.906	2.388E+02
99-Tc	Technetium-99	98.906	1.695E-02
Ag+	Silver Ion	107.868	n/a
Al(OH) ₄ -	Aluminum Hydroxide	95.011	n/a
Al ³⁺	Aluminum Ion	26.982	n/a
As ⁵⁺	Arsenic Ion	74.922	n/a
B ³⁺	Boron Ion	10.810	n/a
Ba ²⁺	Barium Ion	137.340	n/a
Be ²⁺	Beryllium Ion	9.012	n/a
Bi ³⁺	Bismuth Ion	208.981	n/a
C ₁₀ H ₁₂ N ₂ O ₈ -4	EDTA	288.213	n/a
C ₁₀ H ₁₅ N ₂ O ₇ -3	N-Hydroxyethylethylenediaminetriacetate	275.238	n/a
C ₁₂ H ₂₇ O ₄ P	Phosphoric Acid Tributyl Ester	266.317	n/a
C ₁₃ H ₂₈	Tridecane	184.364	n/a
C ₂ Cl ₄	Tetrachloroethene	165.834	n/a
C ₂ H ₃ O ₂ -	Acetate Ion	59.044	n/a
C ₂ H ₃ O ₃ -	Hydroxyacetate Ion	75.044	n/a
C ₂ HCl ₃	Trichloroethylene	131.389	n/a
C ₂ O ₄ -2	Oxalate	88.020	n/a
C ₃ H ₆ O	Acetone	58.080	n/a
C ₄ H ₁₀ O	Ether	74.122	n/a
C ₄ H ₈ O	Methyl Ethyl Ketone	72.107	n/a
C ₅ H ₅ N	Pyridine	79.101	n/a
C ₆ H ₅ NO ₂	Nito-Benzene	123.111	n/a
C ₆ H ₅ O ₇ -3	Citrate Ion	189.101	n/a
C ₆ H ₆	Benzene	78.113	n/a
C ₇ H ₆ N ₂ O ₄	Dinitrotoluene	182.135	n/a
C ₇ H ₈ O	Anisole	108.140	n/a
Ca ²⁺	Calcium Ion	40.080	n/a
Cd ²⁺	Cadmium Ion	112.400	n/a
Ce ³⁺	Cerium Ion	140.120	n/a
CH ₂ Cl ₂	Dichloromethane	84.933	n/a
CHCl ₃	Trichloromethane	119.378	n/a
CHO ₂ -	Formate Ion	45.018	n/a
Cl-	Chloride Ion	35.453	n/a
CN-	Cyanide Ion	26.018	n/a
Co ³⁺	Cobalt Ion	58.933	n/a
CO ₃ -2	Carbonate Ion	60.009	n/a
Cr(OH) ₄ -	Chromium Hydroxide	120.025	n/a
Cr(TOTAL)	Chromium	51.996	n/a
Cs+	Cesium ion	137.000	n/a

Liquid/Solid Components	Component Name	Molecular Weight (kg/kg-mole)	Specific Activity (Ci/gram)
Cu+2	Copper Ion	63.546	n/a
F-	Fluoride Ion	18.998	n/a
Fe+3	Iron Ion	55.847	n/a
H+	Hydrogen Ion	1.008	n/a
H2O	Water	18.015	n/a
H2O2	Hydrogen Peroxide	34.015	n/a
Hg+2	Mercury Ion	200.590	n/a
K+	Potassium Ion	39.090	n/a
La+3	Lanthanum Ion	138.905	n/a
Li+	Lithium Ion	6.940	n/a
Mg+2	Magnesium Ion	24.305	n/a
Mn+4	Manganese Ion	54.938	n/a
MnO2	Manganese Oxide	86.937	n/a
MnO4-	Permanganate Ion	118.936	n/a
Mo+6	Molybdenum Ion	95.940	n/a
Na+	Sodium Ion	22.990	n/a
Nd+3	Neodymium Ion	144.240	n/a
NH3	Ammonia	17.030	n/a
Ni+2	Nickel Ion	58.710	n/a
NO2-	Nitrite	46.005	n/a
NO3-	Nitrate	62.005	n/a
OH(BOUND)	Bound Hydroxide	17.007	n/a
OH-	Hydroxide	17.007	n/a
Pb+2	Lead Ion	207.200	n/a
Pd+2	Palladium Ion	106.400	n/a
PO4-3	Phosphate Ion	94.971	n/a
Pr+3	Praseodymium Ion	140.908	n/a
Pu+4	Plutonium Ion	239.000	n/a
Rb+	Rubidium Ion	85.467	n/a
Rh+3	Rhodium Ion	102.906	n/a
Ru+3	Ruthenium Ion	101.070	n/a
Sb+5	Antimony Ion	121.750	n/a
Se+6	Selenium Ion	78.960	n/a
Si+4	Silicon Ion	28.086	n/a
SO4-2	Sulfate Ion	96.058	n/a
Sr+2	Strontium Ion	90.000	n/a
Ta+5	Tantalum Ion	180.947	n/a
Tc+7	Technetium Ion	98.906	n/a
Te+6	Tellurium Ion	127.600	n/a
Th+4	Thorium Ion	232.038	n/a
Ti+4	Titanium Ion	47.900	n/a
Tl+3	Thallium Ion	204.370	n/a
TOC	Total Organic Carbon	12.011	n/a
U(TOTAL)	Uranium	238.029	n/a
V+5	Vanadium Ion	50.941	n/a
W+6	Tungsten Ion	183.850	n/a
Y+3	Yttrium Ion	88.906	n/a

Liquid/Solid Components	Component Name	Molecular Weight (kg/kg-mole)	Specific Activity (Ci/gram)
Zn+2	Zinc Ion	65.380	n/a
Zr+4	Zirconium Ion	91.220	n/a
C10H8	Naphthalene	128.175	n/a
C12H4Cl6	PCBs	360.884	n/a
C12H8	Acenaphthylene	152.198	n/a
C2H3N	Acetonitrile	41.053	n/a
C2H6SiO	Dimethylsiloxane	74.156	n/a
C2H8N2	1,1-Dimethylhydrazine	60.099	n/a
H2O(BOUND)	Bound Water	18.015	n/a
C4H7NO4	Iminodiacetic Acid	133.105	n/a
C6H6O	Phenol	94.114	n/a
C7H8	Toluene	92.142	n/a
C8H8O	Acetophenone	120.152	n/a
CCl4	Carbon Tetrachloride	153.823	n/a
H2CO3	Carbonic Acid	62.025	n/a
HCO3-	Hydrogen Carbonate Ion	61.017	n/a
Mnp	Process Manganese Ion	54.938	n/a
Nap+	Process Sodium Ion	22.990	n/a
NH4+	Ammonium Ion	18.039	n/a
O-2	Oxide Ion	15.999	n/a
Al(OH)3	Gibbsite	78.004	n/a
PO4-3(HARD)	Hard to Dissolve Phosphate	94.971	n/a
PPG	Polypropyleneglycol	3,503	n/a
DPPG	Decomposed Polypropyleneglycol	3,503	n/a
PDMS	Polydimethoysiloxane	35,015	n/a
DPDMS	Decomposed Polydimethoysiloxane	35,015	n/a
NO3-D	Nitrate (Charge Balance)	62.005	n/a
AlOOH	Boehmite	59.988	n/a
LS9	Liquid-Solid-9	0.000	n/a
LS10	Liquid-Solid-10	0.000	n/a

Table A-2 Gas Components

Gas Components	Component Name	Molecular Weight
CO2	Carbon Dioxide	44.010
H2O	Water	18.015
HCl	Hydrogen Chloride	36.461
HF	Hydrogen Fluoride	20.006
N2	Nitrogen	28.013
NH3	Ammonia	17.030
NO	Nitrogen Oxide	30.006
NO2	Nitrogen Dioxide	46.005
O2	Oxygen	31.999
P2O5	Phosphate	141.945
SO2	Sulfur Dioxide	64.059
129-I	Iodine-129	128.905
SO3	Sulfur Trioxide	80.062
C12H4Cl6	PCBs	360.852

Gas Components	Component Name	Molecular Weight
C2H3N	Acetonitrile	41.054
Hg	Mercury	200.59

Table A-3 Oxide Components

Oxide Components	Component Name	Molecular Weight
Ac2O3	Actinium Oxide	501.998
Ag2O	Silver Oxide	231.735
Al2O3	Aluminum Oxide	101.961
Am2O3	Americium Oxide	533.998
As2O5	Arsenic Oxide	229.840
B2O3	Boron Oxide	69.618
BaO	Barium Oxide	153.339
BeO	Beryllium Oxide	25.012
Bi2O3	Bismuth Oxide	465.960
CaO	Calcium Oxide	56.079
CdO	Cadmium Oxide	128.399
Ce2O3	Cerium Oxide	328.2382
Cl-	Chloride ion	35.453
Cm2O3	Curium Oxide	541.998
CoO	Cobalt Oxide	74.9326
Cr2O3	Chromium Oxide	151.990
Cs2O	Cesium Oxide	289.999
CuO	Copper Oxide	79.545
Dy2O3	Dysprosium Oxide	372.998
Eu2O3	Europium Oxide	351.918
F-	Fluoride ion	18.998
Fe2O3	Iron Oxide	159.692
HgO	Mercury Oxide	216.589
K2O	Potassium Oxide	94.179
La2O3	Lanthanum Oxide	325.809
Li2O	Lithium Oxide	29.879
MgO	Magnesium Oxide	40.304
MnO	Manganese Oxide	70.9374
MoO3	Molybdenum Oxide	143.938
Na2O	Sodium Oxide	61.979
Nb2O5	Niobium Oxide	265.810
Nd2O3	Neodymium Oxide	336.478
NiO	Nickel Oxide	74.709
NpO2	Neptunium Oxide	269.047
P2O5	Phosphate	141.945
PbO	Lead Oxide	223.199
PdO	Palladium Oxide	122.399
Pr2O3	Praseodymium Oxide	329.814
PuO2	Plutonium Oxide	270.999
Rb2O	Rubidium Oxide	186.933
Re2O7 ^(a)	Rhenium Oxide	484.3958
Rh2O3	Rhodium Oxide	253.809
RuO2	Ruthenium Oxide	133.0688

Oxide Components	Component Name	Molecular Weight
Sb2O3	Antimony Oxide	291.498
SeO2	Selenium Oxide	110.959
SiO2	Silicon Dioxide	60.085
Sm2O3	Samarium Oxide	348.798
SnO2	Tin Oxide	150.689
SO3	Sulfur Trioxide	80.058
SrO	Strontium Oxide	105.999
Ta2O5	Tantalum Oxide	441.891
Tc2O7	Technetium Oxide	309.808
TeO2	Tellurium Oxide	159.599
ThO2	Thorium Oxide	264.037
TiO2	Titanium Oxide	79.899
Tl2O	Thallium Oxide	424.7394
UO3	Uranium Oxide	286.0282
V2O5	Vanadium Oxide	181.879
WO3	Tungsten Oxide	231.848
Y2O3	Yttrium Oxide	225.810
ZnO	Zinc Oxide	81.379
ZrO2	Zirconium Oxide	123.219
CO2	Carbon Dioxide	44.010
H2O(Bound)	Bound Water	18.015
H2O	Water	18.015
HfO2	Hafnium Oxide	210.489
Mnp2O3	Process Manganese Oxide	157.875
Nap2O	Process Sodium Oxide	61.979
I29-I	Iodine-129	128.905
Pa2O3	Protactinium Oxide	510.000
RaO	Radium Oxide	242.000
C12H22O11	Sugar	342.299
Ox5	Oxide-5	0.000

^(a) Rhenium oxide is tracked but not used in the model as the TFC feed vector does not provide the quantities of rhenium.

Appendix B

Chemical Adds

Appendix B

Chemical Adds

Chemical reagents including chemicals, minerals, and air are used in various systems and unit operations. Utilization of these chemical reagents is discussed below in a system-by-system manner. Process water and process condensate for line flushes are excluded in these discussions but can be found in Sections 4.7.13 and 4.8. It shall be noted in the following that Na⁺ represents the waste sodium from the Tank Farm and includes the sodium for caustic leach and aluminum solubility applications, Nap⁺ represents the process sodium such as the chemical reagents utilized in other parts of the WTP, and Mnp represents the process manganese. All of the caustic soda contains 2 wt% of NapCl or NaCl as appropriate.

To quickly evaluate the utilization of the chemical reagents, the model can output the initial and final volumes of these chemical reagents for any scenario runs. Table B-23 provides the initial volumes of the chemical reagents in Version 7.0 of the Dynamic (G2) Model.

WASTE FEED RECEIPT PROCESS SYSTEM

Table B-1 Chemical Reagents for FRP/HLP-VSL-00022

Chem Add	Composition	Flowrate	Description
INHIBITED-WATER	0.1M NapOH 0.011M NapNO ₂	73 gpm	Pre- and post- Tank Farm batch transfer line flush

WASTE FEED EVAPORATION PROCESS SYSTEM

Table B-2 Chemical Reagents for FEP

Chem Add	Composition	Flowrate	Description
Antifoam Agent	0.034M PPG 0.003M PDMS	50 gpm	Mitigates foaming in process vessels, Target concentrations: PPG = 250 ppm PDMS = 250 ppm
FEP-DMST-00001A-AIR	Air (0.0012 wt% H ₂ O, 76.7 wt% N ₂ , 23.3 wt% O ₂)	5 ft ³ /min T = 70 °F, P = 14.7 psi	Pump when FEP-SEP-00001A boils off
FEP-DMST-00001B-AIR	Air (0.0012 wt% H ₂ O, 76.7 wt% N ₂ , 23.3 wt% O ₂)	5 ft ³ /min T = 70 °F, P = 14.7 psi	Pump when FEP-SEP-00001B boils off
FEPA-INTER-AFTER-CONDENSER-WATER	H ₂ O	0.96 gpm	Pump when FEP-SEP-00001A boils off
FEPB-INTER-AFTER-CONDENSER-WATER	H ₂ O	0.96 gpm	Pump when FEP-SEP-00001B boils off

ULTRAFILTRATION PROCESS SYSTEM

Table B-3 Reserved Chemical Reagent Capabilities for Envelope C Feeds

Chem Add	Composition	Flowrate	Description
STR-MXR-00001	1M Sr(NO ₃) ₂	n/a	WTP legacy design capability (not used in the model)

Chem Add	Composition	Flowrate	Description
SPR-MXR-00001	1M Nap(MnpO ₄)	n/a	WTP legacy design capability (not used in the model)

Table B-4 Chemical Reagents for UFP-VSL-00001A/B

Chem Add	Composition	Flowrate	Description
Antifoam Agent	0.034M PPG 0.003M PDMS	50 gpm	Mitigates foaming in process vessels, Target concentrations: PPG = 175 ppm PDMS = 175 ppm
STEAM	H ₂ O	variable gpm	Utilized for heating, volume = batch size dependent
DIW-TK-00001	H ₂ O	73 gpm	Reserved capability for sodium dilution
SHR-TK-00006	19M NaOH	50 gpm	Reserved capability for caustic leaching

Table B-5 Chemical Reagents for UFP-VSL-00002A/B

Chem Add	Composition	Flowrate	Description
Antifoam Agent	0.034M PPG 0.003M PDMS	50 gpm	Mitigate foaming in process vessels, Target concentrations: PPG = 175 ppm PDMS = 175 ppm
SHR-TK-00006	19M NaOH	50 gpm	Utilized for caustic leaching and aluminum solubility, volume = batch size and waste composition dependent
STEAM	H ₂ O	variable gpm	Utilized for heating and reaction temperature maintaining, volume = batch size dependent
OXIDATIVE-LEACH- CAUSTIC	2M NapOH	87.5 gpm	Used for oxidative leach, volume = batch size and composition dependent, endpoint = 0.2M [OH-]
SPR-MXR-00001	1M Nap(MnpO ₄)	22 gpm	Used for oxidative leach, volume = calculated, endpoint = (MnO ₄ - to solid chromium mole ratio equal to 1.1)
NAR-TK-00006	2M HNO ₃	87.5 gpm	Used for acid cleaning, volume = 17,076 gal
NEUTRALIZATION- CAUSTIC	19M NapOH	87.5 gpm	Used for neutralizing acids from filter cleaning, volume = 50 gal
DIW-TK-00001	H ₂ O	73 gpm	Secondary source for washing. Primary source is process condensate from RLD-TK-00006A
INHIBITED-WATER	0.1M NapOH 0.011M NapNO ₂	73 gpm	Power flush, UFP1 to UFP2 transfer line flush
UFP-02A-P2-NAOH	0.1M NapOH	87.5 gpm	Post isolation valve pipe = 1,576 gal initially filled before startup

Table B-6 Chemical Reagents for Super Tank

Chem Add	Composition	Flowrate	Description
SHR-TK-00006	19M NaOH	50 gpm	Used to prevent aluminate -> gibbsite reaction, volume = waste composition dependent
DIW-TK-00001	H ₂ O	73 gpm	Secondary source for sodium dilution, dilution endpoint = 8M [Na ⁺]. Primary source is process condensate from RLD-TK-00006A
Steam	H ₂ O	variable gpm	Heating

CESIUM REMOVAL USING ION EXCHANGE PROCESS SYSTEM**Table B-7 Chemical Reagents for CXP**

Chem Add	Composition	Flowrate	Description
SHR-TK-00005 to CXP-VSL-00005	0.1M NapOH	5 gpm	Replenish CXP-VSL-00005 for displacement
DIW-IXC-RINSE-1	H ₂ O	30 gpm	Pre-elution rinse, volume = 2 cv
NAR-TK-00006 through CNP-VSL-00004	0.45M HNO ₃	10 gpm 30 gpm	Elution, volume = 15 cv Resin outlet flush, volume = 21 gal
DIW-IXC-RINSE-2	H ₂ O	10 gpm	Post-elution rinse, volume = 2.5 cv
SHR-TK-00005 to CXP-IXC-00001/2/3/4	0.5M NapOH	27.8 gpm	Regeneration, volume = 4.292 cv
IX-Caustic	0.5M NapOH	30 gpm	Resin outlet flush, volume = 21 gal
IX-DI-Water	H ₂ O	30 gpm	Resin outlet flush, volume = 21 gal
SHR-TK-00005 to CXP-FILT-00001	0.1M NapOH	5 gpm	Guard filter backflush, volume = 80 gal

1 cv = 600 gallons

CESIUM NITRIC ACID RECOVERY PROCESS SYSTEM**Table B-8 Chemical Reagents for CNP**

Chem Add	Composition	Flowrate	Description
NAR-TK-00006	0.45M HNO ₃	87.5 gpm	Replenish CNP-VSL-00004 for IX elution and resin outlet flush
NAR-TK-00005	5M HNO ₃	10 gpm	Volume = 2,128 gallons initially before startup and after each evaporator concentrate discharge

CESIUM FRESH RESIN ADDITION/SPENT RESIN COLLECTION AND DEWATERING PROCESS SYSTEMS

Table B-9 Chemical Reagents for CRP/RDP

Chem Add	Composition	Flowrate	Description
DIW-TK-00004	H ₂ O	20 gpm	Fresh resin preparation, volume = 180 gal
NAR-MXR-00003	0.5M HNO ₃	40 gpm	WTP legacy design capability (not used in the model)
SHR-TK-00004	2M NapOH	20 gpm	Fresh resin preparation, volume = 750 gal
RF-RESIN	R-H	600 gal/batch	Hydrogen ion attached to fresh RF resin, H ⁺ = 4.63 kg-mole
RDP-VSL-00002A- CAUSTIC	0.25M NapOH	140 gpm	Spent resin flush solution, initially before startup, volume = 7,500 gallons

TREATED LAW EVAPORATION/CONCENTRATE STORAGE PROCESS SYSTEMS

Table B-10 Chemical Reagents for TLP/TCF

Chem Add	Composition	Flowrate	Description
Antifoam Agent	0.034M PPG 0.003M PDMS	50 gpm	Mitigates foaming in process vessels, Target concentrations: PPG = 250 ppm PDMS = 250 ppm
SHR-TK-00007	5M NapOH	30 gpm	Used for pH adjustment, target pH = 12, Volume = variable
TLP-DMST-00001-AIR	Air (0.0012 wt % H ₂ O, 76.7 wt % N ₂ , 23.3 wt % O ₂)	5 ft ³ /min T = 70 °F, P= 14.7 psi	Pump when evaporator boils off
TLP-INTER-AFTER-CON DENSER-WATER	H ₂ O	0.96 gpm	Pump when evaporator boils off

PRETREATMENT VESSEL VENT PROCESS SYSTEM

Table B-11 Chemical Reagents for PVP/PJV

Chem Add	Composition	Flowrate	Description
AIR-VENT-LUMP-SUM	Air (0.0012 wt % H ₂ O, 76.7 wt % N ₂ , 23.3 wt % O ₂)	1513 ft ³ /min T = 77 °F, P= 14.7 psi	Continuous
UFV-HLP-3HR- ROTATION	Air (0.0012 wt % H ₂ O, 76.7 wt % N ₂ , 23.3 wt % O ₂)	varies (initial value = 2001.9 ft ³ /min) T = 77 °F, P= 14.7 psi	Rotational flowrate is used from hour 1 to hour 2 to hour 3
SHR-TK-00007	0.01M NapOH	70 gpm	Fill to set volume after PVP-SCB-00002 is discharged
DIW-TK-00004 to PJV- VSL-00001	n/a	n/a	Chemical addition not modeled

Chem Add	Composition	Flowrate	Description
DIW-TK-00004 to PVP-HEME-00001	H ₂ O	0.133 gpm	Continuous

RADIOACTIVE LIQUID DISPOSAL SYSTEM - Pretreatment

None

HLW LAG STORAGE AND FEED BLENDING PROCESS SYSTEM

Table B-12 Chemical Reagents for HLP

Chem Add	Composition	Flowrate	Description
Antifoam Agent	0.034M PPG 0.003M PDMS	50 gpm	Mitigates foaming in process vessels, Target concentrations: PPG = 175 ppm PDMS = 175 ppm
INHIBITED-WATER	0.1M NapOH 0.011M NapNO ₂	73 gpm	Line flush after solid discharge
HLP14	19M NapOH	50 gpm	Used for neutralizing CNP evaporator bottoms, volume = (OH ⁻ to H ⁺ mole ratio = 1.1)

PLANT WASH AND DISPOSAL SYSTEM

Table B-13 Chemical Reagents for PWD

Chem Add	Composition	Flowrate	Description
INHIBITED-WATER	0.1M NapOH 0.011M NapNO ₂	73 gpm	Line flush from Tank Farm
SHR-TK-00006 to PWD-VSL-00015/00016/00044	19M NapOH	26.4 gpm	Volume = variable until pH >= 12

LAW CONCENTRATE/FEED PROCESS SYSTEMS (LCP/LFP)

Table B-14 Chemical Reagents for LCP/LFP

Chem Add	Composition	Flowrate	Description
RHEOLOGY-WATER	H ₂ O	100 gpm	Volume = variable until 36 wt % H ₂ O in the LAW MFPVs

LAW MELTER PROCESS AND LAW PRIMARY OFFGAS PROCESS SYSTEMS (LMP/LOP)

Table B-15 Chemical Reagents for LMP/LOP

Chem Add	Composition	Flowrate	Description
LMP-MLTR-00001-AIR	Air (0.0012 wt % H ₂ O, 76.7 wt% N ₂ , 23.3 wt % O ₂)	946 ft ³ /min T = 68 °F, P= 14.7 psi	Continuously after melter starts,
LMP-MLTR-00002-AIR	Air (0.0012 wt % H ₂ O, 76.7 wt% N ₂ , 23.3 wt % O ₂)	946 ft ³ /min T = 68 °F, P= 14.7 psi	Continuously after melter starts,
LMP-MLTR-00001-WATER	H ₂ O	0.007 gpm	Film cooler water rinse, continuously after melter starts
LMP-MLTR-00002-WATER	H ₂ O	0.007 gpm	Film cooler water rinse, continuously after melter starts
LOP-SCB-00001-WATER	H ₂ O	30 gpm	Volume = 451 gal (SBS Condensate Vessel) initially before startup
LOP-SCB-00002-WATER	H ₂ O	30 gpm	Volume = 451 gal (SBS Condensate Vessel) initially before startup
LOP09	H ₂ O	0.75 gpm	Continuous

LAW SECONDARY OFFGAS PROCESS SYSTEM (LVP)

Table B-16 Chemical Reagents for LVP

Chem Add	Composition	Flowrate	Description
LAW-VESEL-VENT-AIR	74.7 mole % N ₂ , 19.9 mole % O ₂ , and 5.4 mole % H ₂ O	368 ft ³ /min T = 118.3 °F P = 14.7 psi	Continuous,
AMR-VSL-00001-2-NH3	NH ₃ gas	0.5 ft ³ /min T = 100 °F P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.
AMR-VSL-00001-2-AIR	74.7 mole % N ₂ , 19.9 mole % O ₂ , and 5.4 mole % H ₂ O	700 ft ³ /min T = 100 °F P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.

LAW RADIOACTIVE LIQUID DISPOSAL

Table B-17 Chemical Reagents for LAW RLD

Chem Add	Composition	Flowrate	Description
LVP-VSL-00001-NAOH	5M NaOH	20 gpm	Filled to half way between set volume (6,032 gal) and minimum volume (2,032 gal) with NaOH and H ₂ O to pH = 9.0 initially, 20 gallons are added incrementally after to keep pH >= 9.0
LVP-VSL-00001-WATER	H ₂ O	22 gpm	Filled to half way between set volume (6,032 gal) and minimum volume (2,032 gal) with NaOH and H ₂ O to pH = 9.0 initially, enough volume will added to keep SpG < 1.1

HLW FEED PROCESS SYSTEMS

Table B-18 Chemical Reagents for HFP

Chem Add	Composition	Flowrate	Description
RHEOLOGY-HLW	H ₂ O	100 gpm	Volume = variable, target oxide concentration = 550 g/liter in the HLW MFPVs

HLW MELTER PROCESS/HLW PRIMARY OFFGAS PROCESS SYSTEMS

Table B-19 Chemical Reagents for HMP/HOP

Chem Add	Composition	Flowrate	Description
HMP-MLTR-00001-AIR	Combined wet and dry air (0.78 mole% H ₂ O, 78.4 mole% N ₂ , 20.8 mole% O ₂)	711.5 ft ³ /min T = 68 °F P = 14.696 psi	Air to HLW melter, continuous
HMP-MLTR-00002-AIR	Combined wet and dry air (0.78 mole% H ₂ O, 78.4 mole% N ₂ , 20.8 mole% O ₂)	711.5 ft ³ /min T = 68 °F P = 14.696 psi	Air to HLW melter, continuous
HOP08-1	H ₂ O	30 gpm	Volume = 1,758 gal to SBS Condensate vessel initially before startup. Added to SBS at minimum volume as needed if volume goes below 1,758 gal due to evaporation
HOP08-2	H ₂ O	30 gpm	Volume = 1,758 gal to SBS Condensate vessel initially before startup. Added to SBS at minimum volume as needed if volume goes below 1,758 gal due to evaporation
DIW-TK-00002 to HOP-WESP-00001/00002	H ₂ O	0.42 gpm	Continuous
HLW-VESSEL-VENT-1-AIR	79 mole% N ₂ , 21 mole% O ₂ , and 0.002 mole% H ₂ O	131.5 ft ³ /min	Continuous T = 95 °F P = 14.7 psi
HLW-VESSEL-VENT-2-AIR	79 mole% N ₂ , 21 mole% O ₂ , and 0.002 mole% H ₂ O	131.5 ft ³ /min	Continuous T = 95 °F P = 14.7 psi
DIW-TK-00002 to HOP-HEME-00001/00002	H ₂ O	0.15 gpm	Continuous
HOP-SCR-00001-NH ₃	NH ₃ gas	1 ft ³ /min, T = 70 °F, P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.
HOP-SCR-00001-AIR	74.7 mole % N ₂ , 19.9 mole % O ₂ , and 5.4 mole % H ₂ O	200 ft ³ /min, T = 70 °F, P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.
HOP-SCR-00002-NH ₃	NH ₃ gas	1 ft ³ /min, T = 70 °F, P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.

Chem Add	Composition	Flowrate	Description
HOP-SCR-00002-AIR	74.7 mole % N ₂ , 19.9 mole % O ₂ , and 5.4 mole % H ₂ O	200 ft ³ /min, T = 70 °F, P = 100 psi	Variable quantity depending on the kg-moles of NO, NO ₂ , and NH ₃ in the offgas stream.

HLW CANISTER DECONTAMINATION HANDLING SYSTEM

Table B-20 Chemical Reagents for HDH

Chem Add	Composition	Flowrate	Description
HDH-VSL-00001-WATER	H ₂ O	90 gpm	Rinse 1, volume = 180 gal Rinse 2, volume = 180 gal
NAR-TK-00001 ^(a)	1.001M HNO ₃	32 gpm	Decon volume = 194 gal Acid rinse volume = 201gal
HDH-TK-00002 ^(a)	0.5M Ce(NO ₃) ₃	3.2 gpm	Decon, volume = 20 gal
DIW-TK-00002 ^(a)	H ₂ O	33 gpm	Canister spray volume = 200 gal
SHR-TK-00002	5M NaOH	2 gpm	Neutralization volume = 83 gal
HPS	H ₂ O	(initially set to 0.0 gpm) 0.27 gpm 1 gpm 1 gpm 1 gpm	1st use volume = 122 gal 2nd use volume = 5.6 gal 3rd use volume = 5.6 gal 4th use volume = 5.6 gal
HDH-VSL-00003-FLUSH	H ₂ O	31 gpm	Not used
HDH-TK-00003	1M H ₂ O ₂	0.08 gpm	Ce ⁺⁴ neutralization, volume = 0.5 gal

^(a) Chem add supplied to HDH-VSL-00002 and HDH-VSL-00004

HLW RADIOACTIVE LIQUID DISPOSAL PROCESS SYSTEM

Table B-21 Chemical Reagents for HLW RLD

Chem Add	Composition	Flowrate	Description
SHR-TK-00002	5M NaOH	20 gpm	Volume = variable until pH >= 8

GLASS FORMER FACILITY

Table B-22 Glass Formers

Chem Add	Primary Composition	Flowrate	Description
BORAX	B ₂ O ₃	instant	Stockpile, contains mineral impurities
BORIC-ACID	B ₂ O ₃	instant	Stockpile, contains mineral impurities
IRON-OXIDE	Fe ₂ O ₃	instant	Stockpile, contains mineral impurities
KYANITE	Al ₂ O ₃	instant	Stockpile, contains mineral impurities
LITHIUM-CARBONATE	Li ₂ O	instant	Stockpile, contains mineral impurities
OLIVINE	MgO	instant	Stockpile, contains mineral impurities
RUTILE	TiO ₂	instant	Stockpile, contains mineral impurities

Chem Add	Primary Composition	Flowrate	Description
SILICA	SiO ₂	instant	Stockpile, contains mineral impurities
SODA-ASH	Na ₂ O	instant	Stockpile, contains mineral impurities
SUGAR	C ₁₂ H ₂₂ O ₁₁	instant	Stockpile, contains mineral impurities
WOLLASTONITE	CaO	instant	Stockpile, contains mineral impurities
ZINC-OXIDE	ZnO	instant	Stockpile, contains mineral impurities
ZIRCON-SAND	ZrSiO ₄	instant	Stockpile, contains mineral impurities
DUSTING-WATER	H ₂ O	100 gpm	Glass former mixer dusting

CHEMICAL REAGENT INITIAL VOLUMES

Table B-23 Chemical Reagent Initial Volumes

Liquid Reagents

Chem Add Name	ChemAdd Alternate Name	Volume (gal)
FEPB-INTER-AFTER-CONDENSER-WATER	FEPB-INTER-AFTER-CONDENSER-WATER	9.99890E+07
FEPA-INTER-AFTER-CONDENSER-WATER	FEPA-INTER-AFTER-CONDENSER-WATER	9.99890E+07
HDH-VSL-00003-FLUSH	V33002-STEAM-EJECTOR	9.99890E+07
DIW-TK-00002	H2O-CHEM-ADD-1	9.99890E+07
HDH-TK-00002	DECON-CE4-CHEM-ADD-1	9.50573E+07
NAR-TK-00001	DECON-NITRIC-ACID-CHEM-ADD-1	9.78791E+07
HDH-TK-00003	HYDROGEN-PEROXIDE	9.89732E+07
HPS	V33002-STEAM-CONDENSATE	9.99890E+07
SHR-TK-00002	V33002-NAOH-ADD	9.43030E+07
DIW-TK-00002	H2O-CHEM-ADD	9.99890E+07
HDH-TK-00002	DECON-CE4-CHEM-ADD	9.50573E+07
HDH-VSL-00001-WATER	BOGIE-RINSE-H2O	9.99890E+07
NAR-TK-00001	DECON-NITRIC-ACID-CHEM-ADD	9.78791E+07
DIW-TK-00002	HEME-WATER-2	9.99890E+08
HOP08-2	SBS-1-WATER-2	9.99890E+07
DIW-TK-00002	WESP-LIQUID-2	9.99890E+08
DIW-TK-00002	HEME-WATER-1	9.99890E+08
HOP08-1	SBS-1-WATER-1	9.99890E+07
DIW-TK-00002	WESP-LIQUID-1	9.99890E+08
LMP-MLTR-00001-WATER	LAW-MELTER-WATER-1	9.99890E+07
LOP-SCB-00001-WATER	LAW-SBS-CHEM-ADD-1	9.99890E+07
LOP09	LAW-WESP-CHEM-ADD-1	9.99890E+08
RHEOLOGY-HLW	RHEOLOGY-HLW	9.99890E+07
LMP-MLTR-00002-WATER	LAW-MELTER-WATER-2	9.99890E+07
LOP-SCB-00002-WATER	LAW-SBS-CHEM-ADD-2	9.99890E+07
LOP09	LAW-WESP-CHEM-ADD-2	9.99890E+08
LVP-VSL-00001-WATER	WATER-V22001	9.99890E+08
LVP-VSL-00001-NAOH	NAOH-V22001	9.43030E+07
SHR-TK-00007	PVP-CAUSTIC-SCRUBBER-CHEM-ADD	1.00393E+08
DIW-TK-00004	PJV-DMST-WATER	1.00321E+08
DIW-TK-00004	PVP-HEME-WATER	9.99890E+07

Chem Add Name	ChemAdd Alternate Name	Volume (gal)
SHR-TK-00005	FILTER-BACKFLUSH-CAUSTIC	1.00001E+07
SHR-TK-00001	IX-CAUSTIC	1.00024E+08
IX-DI-WATER	IX-DI-WATER	9.99890E+07
SHR-TK-00005	CAUSTIC-V13008	1.00001E+07
SHR-TK-00005	C5-C13003	1.00024E+08
DIW-IXC-RINSE-2	C4-C13003	9.99890E+07
DIW-IXC-RINSE-1	C2-C13003	9.99890E+07
SHR-TK-00005	C5-C13004	1.00024E+08
DIW-IXC-RINSE-2	C4-C13004	9.99890E+07
DIW-IXC-RINSE-1	C2-C13004	9.99890E+07
SHR-TK-00005	C5-C13001	1.00024E+08
DIW-IXC-RINSE-2	C4-C13001	9.99890E+07
DIW-IXC-RINSE-1	C2-C13001	9.99890E+07
SHR-TK-00005	C5-C13002	1.00024E+08
DIW-IXC-RINSE-2	C4-C13002	9.99890E+07
DIW-IXC-RINSE-1	C2-C13002	9.99890E+07
SHR-TK-00002	V35002-NAOH-ADD	9.43030E+07
SHR-TK-00006	PWD-NEUTRALIZATION-CAUSTIC	9.06675E+07
NAR-TK-00005	ACID-CHARGE	9.23799E+07
NAR-TK-00006	V13028-CHEM-ADD	9.90054E+07
HLP14	HLP14	9.06675E+07
RHEOLOGY-WATER	RHEOLOGY-WATER	9.99890E+07
DUSTING-WATER	DUSTING-WATER	9.99890E+07
ANTIFOAM-AGENT	AFA	1.03036E+07
INHIBITED-WATER	INHIBITED-WATER	2.08252E+08
DIW-TK-00001	DEMIN-WATER-CHEM-ADD	9.99890E+07
OXIDATIVE-LEACH-CAUSTIC	OXIDATIVE-LEACH-CAUSTIC	9.72108E+07
NEUTRALIZATION-CAUSTIC	NEUTRALIZATION-CAUSTIC	9.06675E+07
SHR-TK-00006	UFP-CAUSTIC	9.06674E+07
SPR-MXR-00001	SPR-MXR-00001	9.55658E+07
UFP-02-P2-NAOH	NAOH-UFP-02B-P2	1.00001E+04
UFP-02-P2-NAOH	NAOH-UFP-02A-P2	1.00001E+04
STEAM	UFP-STEAM	9.99890E+07
STR-MXR-00001	SRNITRATE-V12010B	9.39463E+07
SPR-MXR-00001	NAMNO4-V12010B	9.55663E+07
STR-MXR-00001	SRNITRATE-V12010A	9.39463E+07
SPR-MXR-00001	NAMNO4-V12010A	9.55663E+07
NAR-TK-00006	NAR-TK-00006	9.59799E+07
SHR-TK-00007	V45009B-CHEM-ADD	9.43030E+07
SHR-TK-00007	V45009A-CHEM-ADD	9.43030E+07
TLP-INTER-AFTER-CONDENSER-WATER	TLP-INTER-AFTER-CONDENSER-WATER	9.99890E+07
DIW-TK-00004	FRESH-RESIN-WATER	9.99890E+07
SHR-TK-00004	FRESH-RESIN-CAUSTIC	9.72108E+07
RDP-VSL-00002A-CAUSTIC	CAUSTIC-RDP1	9.99361E+07

Gas Reagents

Chem Add Name	ChemAdd Alternate Name	Volume (cubic feet)
FEP-DMST-00001B-AIR	V11002B-CONDENSER-COLLECTION-VENT-GAS	9.99999E+09
FEP-DMST-00001A-AIR	V11002A-CONDENSER-COLLECTION-VENT-GAS	9.99999E+09
RFD-AIR	RFD-AIR	1.00000E+15
PSA	PJM-AIR	1.00000E+15
HOP-SCR-00002-AIR	HOP-SCR-00002-AIR	1.47000E+14
HOP-SCR-00002-NH3	HOP-SCR-00002-NH3	1.47022E+10
HLW-VESSEL-VENT-2-AIR	VESSEL-VENT-AIR-2	1.00000E+15
HMP-MLTR-00002-AIR	HLW-MELTER-AIR-2	9.96589E+14
HOP-SCR-00001-AIR	HOP-SCR-00001-AIR	1.47000E+14
HLW-VESSEL-VENT-1-AIR	VESSEL-VENT-AIR-1	1.00000E+15
HOP-SCR-00001-NH3	HOP-SCR-00001-NH3	1.47022E+10
HMP-MLTR-00001-AIR	HLW-MELTER-AIR-1	9.96589E+14
LMP-MLTR-00001-AIR	LAW-MELTER-AIR-1	9.96492E+14
AMR-VSL-00001-2-AIR	AMR-VSL-00001-2-AIR	1.32781E+11
LAW-VESSEL-VENT-AIR	VESSEL-VENT-AIR	9.32819E+11
AMR-VSL-00001-2-NH3	AMR-VSL-00001-2-NH3	1.99171E+09
LMP-MLTR-00002-AIR	LAW-MELTER-AIR-2	9.96492E+14
UFV-HLP-3HR-ROTATION	UFV-HLP-3HR-ROTATION	1.00000E+15
AIR-VENT-LUMP-SUM	AIR-VENT-LUMP-SUM	1.00000E+15
TLP-DMST-00001-AIR	V41011-CONDENSER-COLLECTION-VENT-GAS	9.99999E+09

Mineral Reagents

Chem Add Name	ChemAdd Alternate Name	Volume (gal)
H3BO3	BORIC-ACID	4.28019E+06
ZNO	ZINC-OXIDE	6.91128E+06
NA2B4O710H2O	BORAX	4.86857E+06
LI2CO3	LITHIUM-CARBONATE	4.39990E+06
NA2CO3	SODA-ASH	3.63993E+06
AL2SIO5	KYANITE	4.16541E+06
CASIO3	WOLLASTONITE	5.03625E+06
FE2O3	IRON-OXIDE	2.62857E+06
ZRSIO4	ZIRCON-SAND	2.89238E+06
SIO2	SILICA	4.71121E+07
TIO2	RUTILE	2.56853E+06
MG2SIO4FE2SIO4	OLIVINE	2.61664E+06
C12H22O11	SUGAR	4.44212E+06

Appendix C

Sample Identification and Logic

Appendix C

Sample Identification and Logic

Instantaneous chemical compositions at specified ISARD sample locations and data reconciliation locations can be collected as requested. The equipment names, sample identification, and sampling logic are described in the tables below, and are listed in order by lab or sample identification.

Table C-1 Sample Identification and Logic for ISARD

Snapshot Filename ⁽¹⁾	ISARD Sample Point ID	Lab OR Sample ID	Vessel	Sample Trigger
CXP1	PT28	38	CXP-VSL-00026A	When vessel volume reaches above upper setpoint
CXP2	PT28	38	CXP-VSL-00026B	When vessel volume reaches above upper setpoint
CXP3	PT28	38	CXP-VSL-00026C	When vessel volume reaches above upper setpoint
FRP1	PT2	9	FRP-VSL-00002A	When vessel is full or Tank Farm transfer is complete
FRP2	PT2	9	FRP-VSL-00002B	When vessel is full or Tank Farm transfer is complete
FRP3	PT2	9	FRP-VSL-00002C	When vessel is full or Tank Farm transfer is complete
FRP4	PT2	9	FRP-VSL-00002D	When vessel is full or Tank Farm transfer is complete
HCP1	HLW1	67	HFP-VSL-00001	Before glass former addition
HCP2	HLW1	67	HFP-VSL-00005	Before glass former addition
HFP1	HLW2	71	HFP-VSL-00001	After glass former addition and prior to discharge
HFP2	HLW2	71	HFP-VSL-00005	After glass former addition and prior to discharge
HLP1	PT17	24	HLP-VSL-00022	When vessel is full or a Tank Farm transfer is complete
HLP4	PT13	19	HLP-VSL-00028	When vessel volume reaches above upper setpoint
LCP1	LAW1	48	LCP-VSL-00001	When vessel volume reaches above upper setpoint
LCP2	LAW1	48	LCP-VSL-00002	When vessel volume reaches above upper setpoint
RDP1	PT31	40	RDP-VSL-00002B	When vessel volume reaches above upper setpoint
RLD1	PT35	43	RLD-VSL-00017A	When vessel volume reaches above upper setpoint
RLD2	PT35	43	RLD-VSL-00017B	When vessel volume reaches above upper setpoint

Table C-2 Sample Identification and Logic

Snapshot Filename	Sample ID	Lab OR Sample ID	Vessel	Sample Trigger
CNP1	PT10	16	CNP-VSL-00004	Once a month when vessel volume is above lower setpoint
CNP2	PT38	46	CNP-EVAP-00001	When target Na molarity is achieved and prior to discharge
FEP1	FEP	102	FEP-VSL-00017A	Prior to discharge
FEP2	FEP	102	FEP-VSL-00017B	Prior to discharge
HDH1	HLW6	74	HDH-VSL-00003	After HLW canister decontamination and prior to discharge
HLP2	PT16F	22	HLP-VSL-00027A	Prior to discharge
HLP3	PT16F	22	HLP-VSL-00027B	Prior to discharge
HOP1	HOP1	111	HOP-VSL-00903	Prior to discharge
HOP2	HOP2	111	HOP-VSL-00904	Prior to discharge
HOP3	HOP3	112	HOP-WESP-00001	Every 3 days & after WESP reactions
HOP4	HOP4	112	HOP-WESP-00002	Every 3 days & after WESP reactions
LFP1	LAW6	108	LFP-VSL-00001	After glass former addition and prior to discharge
LFP2	LAW6	108	LFP-VSL-00003	After glass former addition and prior to discharge
LFP3	LFP3	109	LFP-VSL-00002	After receiving a full batch from MFPV
LFP4	LFP4	109	LFP-VSL-00004	After receiving a full batch from MFPV
LOP1	LOP1	110	LOP-VSL-00001	Prior to discharge
LOP2	LOP2	110	LOP-VSL-00002	Prior to discharge
OF100	OF100	100	SUPPLEMENTAL-LAW-TREATED	Quarterly
OF101	OF101	101	SUPPLEMENTAL-LAW-RECYCLE	Quarterly (Not used, LAW SBS recycle to Supplemental LAW Facility not in baseline)
PVP1	PT7	13	PVP-SCB-00002	Daily
PWD1	PT14	20	PWD-VSL-00015	When vessel is above upper setpoint and prior to discharge
PWD2	PT14	20	PWD-VSL-00016	When vessel is above upper setpoint and prior to discharge
PWD3	PT12A	17	PWD-VSL-00044	When vessel is above upper setpoint and prior to discharge
RLD3	PT27	37	RLD-TK-00006B	When vessel volume reaches above upper setpoint (1st 10 batches, then every 10th batch)
RLD4	LAW8	54	RLD-VSL-00004	When vessel volume reaches above upper setpoint
RLD5	LAW10	56	RLD-VSL-00005	When vessel volume reaches above upper setpoint
RLD6	HLW4B	73	RLD-VSL-00007	When vessel volume reaches above upper setpoint
TCP1	TCP1	107	TCP-VSL-00001	Sample when LAW CRV is sampled
TLP1	PT34	42	TLP-VSL-00009A	When vessel volume reaches above upper setpoint
TLP2	PT34	42	TLP-VSL-00009B	When vessel volume reaches above upper setpoint

Snapshot Filename	Sample ID	Lab OR Sample ID	Vessel	Sample Trigger
TLP3	TLP3	106	TLP-SEP-00001	Sample evaporator bottom when LAW CRV is sampled
UFP1	PT5	11	UFP-VSL-00002A	After oxidative leach and before oxidative wash
UFP2	PT5	11	UFP-VSL-00002B	After oxidative leach and before oxidative wash
UFP3	PT19	28	UFP-VSL-00002A	After solid concentration and before wash
UFP4	PT19	28	UFP-VSL-00002B	After solid concentration and before wash
UFP10	UFP0	104	UFP-VSL-00001A	After leaching and prior to discharge
UFP11	UFP0	104	UFP-VSL-00001B	After leaching and prior to discharge

Appendix D

Component Splits

Appendix D

Component Splits

The primary method for separation of mass is achieved by using splits in the G2 mode, e.g., upon arriving at a separation unit operation an influent is split into two output streams based on the split factors assigned. Splits are primarily applied to liquid and solid components, but are also applied to gas components. Special cases exist such that the separation is handled by reactions or by the combination of reactions and splits. This is especially true for the melters and offgas equipment where the destruction and formation of compounds occur.

The following tables present the split values applied to various WTP equipment where one table is shown if multiple trains of the same equipment exist in a unit operation.

Table D-1 FEP-SEP-00001 Splits

FEP-SEP-00001A/B Components	Liquid/Solid Fractions to FEP-DMST-00001A/B
113m-Cd	0.0000452
125-Sb	0.00025
126-Sn	0.00025
129-I	0.002
134-Cs	3.57E-08
137-Cs	3.57E-08
137m-Ba	3.57E-08
14-C	0.00099
151-Sm	2.67E-07
152-Eu	7.09E-07
154-Eu	7.09E-07
155-Eu	7.09E-07
229-Th	0.00099
232-Th	0.00099
232-U	0.00099
233-U	0.00099
234-U	0.00099
235-U	0.00099
236-U	0.00099
237-Np	0.00099
238-Pu	2.67E-07
238-U	0.00099
239-Pu	2.67E-07
240-Pu	2.67E-07
241-Am	7.09E-07
241-Pu	2.67E-07
242-Cm	0.00099
242-Pu	2.67E-07
243-Am	7.09E-07
243-Cm	0.00099
244-Cm	0.00099
3-H	0.599

**FEP-SEP-00001A/B
Components****Liquid/Solid Fractions
to FEP-DMST-00001A/B**

59-Ni	0.0000339
60-Co	0.00099
63-Ni	0.0000339
90-Sr	4.31E-06
90-Y	4.31E-06
93-Zr	0.00099
99-Tc	0.00099
Ag+	0.00099
Al(OH) ₄ ⁻	0.000658
Al ⁺³	0.000658
As ⁺⁵	0.00099
B ⁺³	0.00099
Ba ⁺²	0.00099
Bi ⁺³	0.00025
C ₁₀ H ₁₂ N ₂ O ₈ ⁻⁴	0.001
C ₁₀ H ₁₅ N ₂ O ₇ ⁻³	0.001
C ₁₂ H ₂₇ O ₄ P	0.001
C ₂ O ₄ ⁻²	0.001
C ₆ H ₅ O ₇ ⁻³	0.09346
Ca ⁺²	0.001
Cd ⁺²	0.0000452
Ce ⁺³	0.00099
Cl ⁻	0.002
Co ⁺³	0.00099
CO ₃ ⁻²	0.00099
Cr(OH) ₄ ⁻	0.0000282
Cr(TOTAL)	0.0000282
Cs ⁺	3.57E-08
Cu ⁺²	0.00099
F ⁻	0.0000411
Fe ⁺³	0.00099
H ⁺	0.1
Hg ⁺²	0.00099
K ⁺	0.000282
La ⁺³	0.00099
Li ⁺	0.000033
Mg ⁺²	0.00099
Mn ⁺⁴	0.00099
MnO ₄ ⁻	0.00099
Na ⁺	0.000033
NH ₃	0.9
Ni ⁺²	0.0000339
NO ₂ ⁻	0.000412
NO ₃ ⁻	0.002
OH(BOUND)	0.00099
OH ⁻	0.00099
Pb ⁺²	0.00025
Pd ⁺²	0.0000339

FEP-SEP-00001A/B Components	Liquid/Solid Fractions to FEP-DMST-00001A/B
PO4-3	0.00099
Pu+4	2.67E-07
Sb+5	0.00025
Si+4	0.00099
SO4-2	0.000704
Sr+2	4.31E-06
Tc+7	0.00099
Th+4	0.00099
Ti+4	0.00099
U(TOTAL)	0.00099
Zn+2	0.00099
Zr+4	0.00099
C12H4Cl6	0.0004
C2H3N	0.969
Mnp	0.00099
Nap+	0.000033
Al(OH)3	0.000658
PO4-3(HARD)	0.00099
PPG	1.00E-08
DPPG	1.00E-08
PDMS	1.00E-08
DPDMS	1.00E-08
AlOOH	0.000658

Table D-2 FEP-DMST-00001 Splits

FEP-DMST-00001A/B Components	Liquid/Solid Fractions to PVP Vessel Vent
113m-Cd	0.002
125-Sb	0.0000358
126-Sn	0.0000358
129-I	0.001
134-Cs	0.0000427
137-Cs	0.0000427
137m-Ba	0.0000427
14-C	0.002
151-Sm	0.00032
152-Eu	0.00032
154-Eu	0.00032
155-Eu	0.00032
229-Th	0.002
232-Th	0.002
232-U	0.002
233-U	0.002
234-U	0.002
235-U	0.002
236-U	0.002
237-Np	0.002

**FEP-DMST-00001A/B
Components****Liquid/Solid Fractions
to PVP Vessel Vent**

238-Pu	0.00032
238-U	0.002
239-Pu	0.00032
240-Pu	0.00032
241-Am	0.00032
241-Pu	0.00032
242-Cm	0.002
242-Pu	0.00032
243-Am	0.00032
243-Cm	0.002
244-Cm	0.002
3-H	0.014
59-Ni	0.002
60-Co	0.002
63-Ni	0.002
90-Sr	0.0000855
90-Y	0.0000855
93-Zr	0.002
99-Tc	0.002
Ag+	0.002
Al(OH) ₄ ⁻	0.002
Al ⁺³	0.002
As ⁺⁵	0.002
B ⁺³	0.002
Ba ⁺²	0.002
Bi ⁺³	0.0000358
C ₁₀ H ₁₂ N ₂ O ₈ ⁻⁴	0.05814
C ₁₀ H ₁₅ N ₂ O ₇ ⁻³	0.05814
C ₁₂ H ₂₇ O ₄ P	0.05814
C ₂ O ₄ ⁻²	0.05814
C ₆ H ₅ O ₇ ⁻³	1.53E-06
Ca ⁺²	0.058
Cd ⁺²	0.002
Ce ⁺³	0.002
Cl ⁻	0.0001299
Co ⁺³	0.002
CO ₃ ⁻²	0.002
Cr(OH) ₄ ⁻	0.000188
Cr(TOTAL)	0.000188
Cs ⁺	0.0000427
Cu ⁺²	0.002
F ⁻	0.00053
Fe ⁺³	0.002
H ⁺	0.01
Hg ⁺²	0.002
K ⁺	0.002
La ⁺³	0.002

FEP-DMST-00001A/B Components	Liquid/Solid Fractions to PVP Vessel Vent
Li+	0.002
Mg+2	0.035
Mn+4	0.002
MnO4-	0.002
Na+	0.002
NH3	0.081
Ni+2	0.002
NO2-	0.0000962
NO3-	0.0000962
OH(BOUND)	0.002
OH-	0.002
Pb+2	0.0000358
Pd+2	0.002
PO4-3	0.002
Pu+4	0.00032
Sb+5	0.0000358
Si+4	0.004
SO4-2	0.0002375
Sr+2	0.0000855
Tc+7	0.002
Th+4	0.002
Ti+4	0.002
U(TOTAL)	0.002
Zn+2	0.002
Zr+4	0.002
C12H4Cl6	0.0004
C2H3N	0.8314
Mnp	0.002
Nap+	0.002
Al(OH)3	0.002
AlOOH	0.002

Table D-3 PVP-SCB-00002 Splits

PVP-SCB-00002 Components	Liquid % to PVP-HEME-00001	Solid % to PVP-HEME-00001
125-Sb	30.03003003	30.03003003
126-Sn	30.03003003	30.03003003
129-I	30.03003003	30.03003003
134-Cs	30.03003003	30.03003003
137-Cs	30.03	30.03
137m-Ba	30.03	30.03
14-C	100	100
151-Sm	30.03003003	30.03003003
152-Eu	30.03003003	30.03003003
154-Eu	30.03003003	30.03003003
155-Eu	30.03003003	30.03003003
232-Th	30.03003003	30.03003003

PVP-SCB-00002	Liquid %	Solid %
Components	to PVP-HEME-00001	to PVP-HEME-00001
233-U	30.03003003	30.03003003
234-U	30.03003003	30.03003003
235-U	30.03003003	30.03003003
236-U	30.03003003	30.03003003
237-Np	30.03003003	30.03003003
238-Pu	30.03003003	30.03003003
238-U	30.03003003	30.03003003
239-Pu	30.03003003	30.03003003
240-Pu	30.03003003	30.03003003
241-Am	30.03003003	30.03003003
241-Pu	30.03003003	30.03003003
243-Cm	30.03003003	30.03003003
244-Cm	30.03003003	30.03003003
3-H	100	100
60-Co	30.03003003	30.03003003
63-Ni	30.03003003	30.03003003
90-Sr	30.03	30.03
90-Y	30.03	30.03
99-Tc	30.03003003	30.03003003
Ag+	30.03003003	30.03003003
Al(OH) ₃	30.03	30.03
Al(OH) ₄ -	30.03003003	30.03003003
Al ³⁺	30.03003003	30.03003003
AlOOH	30.03	30.03
As ⁺⁵	30.03003003	30.03003003
B ⁺³	30.03003003	30.03003003
Ba ⁺²	30.03003003	30.03003003
Bi ⁺³	30.03003003	30.03003003
C ₁₂ H ₄ Cl ₆	33.3	33.3
C ₂ H ₃ N	100	100
C ₂ O ₄ -2	33.33333337	33.33333337
Ca ⁺²	30.03003003	30.03003003
Cd ⁺²	30.03003003	30.03003003
Ce ⁺³	30.03003003	30.03003003
Cl-	30.03003003	30.03003003
CO ₃ -2	33.33333337	33.33333337
Cr(TOTAL)	30.03003003	30.03003003
Cu ⁺²	30.03003003	30.03003003
F-	30.03003003	30.03003003
Fe ⁺³	30.03003003	30.03003003
Hg ⁺²	100	100
K+	30.03003003	30.03003003
La ⁺³	30.03003003	30.03003003
Li+	30.03003003	30.03003003
Mg ⁺²	30.03003003	30.03003003
Mn ⁺⁴	30.03003003	30.03003003
Mnp	30.03	30.03

PVP-SCB-00002	Liquid %	Solid %
Components	to PVP-HEME-00001	to PVP-HEME-00001
Na+	30.03003003	30.03003003
Nap+	30.03	30.03
NH3	33.33333337	33.33333337
Ni+2	30.03003003	30.03003003
NO2-	30.03003003	30.03003003
NO3-	30.03003003	30.03003003
OH(BOUND)	30.03003003	30.03003003
OH-	30.03003003	30.03003003
Pb+2	30.03003003	30.03003003
Pd+2	30.03003003	30.03003003
PO4-3	30.03003003	30.03003003
PO4-3(HARD)	30.03	30.03
Si+4	30.03003003	30.03003003
SO4-2	30.03003003	30.03003003
Sr+2	30.03003003	30.03003003
Ti+4	30.03003003	30.03003003
Zn+2	30.03003003	30.03003003
Zr+4	30.03003003	30.03003003

Table D-4 PVP-HEME-00001 Splits

PVP-HEME-00001	Liquid %	Solid %
Components	to PVP-VSL-00001	to PVP-VSL-00001
125-Sb	99.5	99.5
126-Sn	99.5	99.5
129-I	0.0001	0.0001
134-Cs	99.5	99.5
137-Cs	99.5	99.5
137m-Ba	99.5	99.5
14-C	0.0001	0.0001
151-Sm	99.5	99.5
152-Eu	99.5	99.5
154-Eu	99.5	99.5
155-Eu	99.5	99.5
232-Th	99.5	99.5
233-U	99.5	99.5
234-U	99.5	99.5
235-U	99.5	99.5
236-U	99.5	99.5
237-Np	99.5	99.5
238-Pu	99.5	99.5
238-U	99.5	99.5
239-Pu	99.5	99.5
240-Pu	99.5	99.5
241-Am	99.5	99.5
241-Pu	99.5	99.5
243-Cm	99.5	99.5
244-Cm	99.5	99.5

PVP-HEME-00001 Components	Liquid % to PVP-VSL-00001	Solid % to PVP-VSL-00001
3-H	0.0001	0.0001
60-Co	99.5	99.5
63-Ni	99.5	99.5
90-Sr	99.5	99.5
90-Y	99.5	99.5
99-Tc	99.5	99.5
Ag+	99.5	99.5
Al(OH)3	99.5	99.5
Al(OH)4-	99.5	99.5
Al+3	99.5	99.5
AlOOH	99.5	99.5
As+5	99.5	99.5
B+3	99.5	99.5
Ba+2	99.5	99.5
Bi+3	99.5	99.5
C12H4Cl6	99.5	99.5
C2H3N	0	0
C2O4-2	99.5	99.5
Ca+2	99.5	99.5
Cd+2	99.5	99.5
Ce+3	99.5	99.5
Cl-	99.5	99.5
CO3-2	99.5	99.5
Cr(TOTAL)	99.5	99.5
Cu+2	99.5	99.5
F-	99.5	99.5
Fe+3	99.5	99.5
Hg+2	0.0001	0.0001
K+	99.5	99.5
La+3	99.5	99.5
Li+	99.5	99.5
Mg+2	99.5	99.5
Mn+4	99.5	99.5
Mnp	99.5	99.5
Na+	99.5	99.5
Nap+	99.5	99.5
NH3	0.0001	0.0001
Ni+2	99.5	99.5
NO2-	99.5	99.5
NO3-	99.5	99.5
OH(BOUND)	99.5	99.5
OH-	99.5	99.5
Pb+2	99.5	99.5
Pd+2	99.5	99.5
PO4-3	99.5	99.5
PO4-3(HARD)	99.5	99.5
Si+4	99.5	99.5

PVP-HEME-00001	Liquid %	Solid %
Components	to PVP-VSL-00001	to PVP-VSL-00001
SO4-2	99.5	99.5
Sr+2	99.5	99.5
Ti+4	99.5	99.5
Zn+2	99.5	99.5
Zr+4	99.5	99.5

Table D-5 PVP-HEPA Splits

PVP-HEPA-00001-2	Liquid %	Solid %
Components	to Accumulate	to Accumulate
125-Sb	99.99994001	99.99994001
126-Sn	99.99994001	99.99994001
134-Cs	99.99994001	99.99994001
137-Cs	100	100
137m-Ba	100	100
151-Sm	99.99994001	99.99994001
152-Eu	99.99994001	99.99994001
154-Eu	99.99994001	99.99994001
155-Eu	99.99994001	99.99994001
232-Th	99.99994001	99.99994001
233-U	99.99994001	99.99994001
234-U	99.99994001	99.99994001
235-U	99.99994001	99.99994001
236-U	99.99994001	99.99994001
237-Np	99.99994001	99.99994001
238-Pu	99.99994001	99.99994001
238-U	99.99994001	99.99994001
239-Pu	99.99994001	99.99994001
240-Pu	99.99994001	99.99994001
241-Am	99.99994001	99.99994001
241-Pu	99.99994001	99.99994001
243-Cm	99.99994001	99.99994001
244-Cm	99.99994001	99.99994001
60-Co	99.99994001	99.99994001
63-Ni	99.99994001	99.99994001
90-Sr	100	100
90-Y	100	100
99-Tc	99.99994001	99.99994001
Ag+	99.99994001	99.99994001
Al(OH)3	100	100
Al+3	99.99994001	99.99994001
AlOOH	100	100
As+5	99.99994001	99.99994001
B+3	99.99994001	99.99994001
Ba+2	99.99994001	99.99994001
Bi+3	99.99994001	99.99994001
C12H4Cl6	98	98
C2H3N	0	0

PVP-HEPA-00001-2	Liquid %	Solid %
Components	to Accumulate	to Accumulate
C2O4-2	99.99994001	99.99994001
Ca+2	99.99994001	99.99994001
Cd+2	99.99994001	99.99994001
Ce+3	99.99994001	99.99994001
Cl-	99.99994001	99.99994001
CO3-2	99.99994001	99.99994001
Cr(TOTAL)	99.99994001	99.99994001
Cu+2	99.99994001	99.99994001
F-	99.99994001	99.99994001
Fe+3	99.99994001	99.99994001
K+	99.99994001	99.99994001
La+3	99.99994001	99.99994001
Li+	99.99994001	99.99994001
Mg+2	99.99994001	99.99994001
Mn+4	99.99994001	99.99994001
Mnp	100	100
Na+	100	100
Nap+	100	100
Ni+2	99.99994001	99.99994001
NO2-	99.99994001	99.99994001
NO3-	99.99994001	99.99994001
OH-	99.99994001	99.99994001
Pb+2	99.99994001	99.99994001
Pd+2	99.99994001	99.99994001
PO4-3	99.99994001	99.99994001
PO4-3(HARD)	100	100
Si+4	99.99994001	99.99994001
SO4-2	99.99994001	99.99994001
Sr+2	99.99994001	99.99994001
Ti+4	99.99994001	99.99994001
Zn+2	99.99994001	99.99994001
Zr+4	99.99994001	99.99994001
	Gas % to	
Gas Components	ACCUMULATE	
CO2		0

Table D-6 PVP-Thermal-Oxidizer Splits

PVP-OXID-00001	Liquid %	Solid %
Components	to Accumulate	to Accumulate
C2O4-2	99	99
	Gas %	
Gas Components	to Accumulate	
CO2		0

Table D-7 PVP-Carbon-Absorber Splits

PVP-ABS-00001AB	Liquid %	Solid %
Components	to Accumulate	to Accumulate
C12H4Cl6	90	90
C2H3N	90	90
C2O4-2	90	90
Hg+2	97.5	97.5
	Gas %	
Gas Components	to Accumulate	
C12H4Cl6	90	
C2H3N	90	
CO2	0	

Table D-8 PJV-VSL-00001 Splits

PJV-VSL-00001	Liquid %	Solid %
Components	to PJV-VSL-00002	to PJV-VSL-00002
125-Sb	99.5	99.5
126-Sn	99.5	99.5
137-Cs	99.5	99.5
137m-Ba	99.5	99.5
151-Sm	99.5	99.5
152-Eu	99.5	99.5
154-Eu	99.5	99.5
155-Eu	99.5	99.5
232-Th	99.5	99.5
233-U	99.5	99.5
234-U	99.5	99.5
235-U	99.5	99.5
236-U	99.5	99.5
237-Np	99.5	99.5
238-Pu	99.5	99.5
238-U	99.5	99.5
239-Pu	99.5	99.5
240-Pu	99.5	99.5
241-Am	99.5	99.5
241-Pu	99.5	99.5
243-Cm	99.5	99.5
244-Cm	99.5	99.5
60-Co	99.5	99.5
63-Ni	99.5	99.5
90-Sr	99.5	99.5
90-Y	99.5	99.5
99-Tc	99.5	99.5
Ag+	99.5	99.5
Al(OH)3	99.5	99.5
Al+3	99.5	99.5
As+5	99.5	99.5
B+3	99.5	99.5
Ba+2	99.5	99.5

PJV-VSL-00001 Components	Liquid % to PJV-VSL-00002	Solid % to PJV-VSL-00002
Bi+3	99.5	99.5
C2O4-2	99.5	99.5
Ca+2	99.5	99.5
Cd+2	99.5	99.5
Ce+3	99.5	99.5
Cl-	99.5	99.5
CO3-2	99.5	99.5
Cr(TOTAL)	99.5	99.5
Cu+2	99.5	99.5
F-	99.5	99.5
Fe+3	99.5	99.5
K+	99.5	99.5
La+3	99.5	99.5
Li+	99.5	99.5
Mg+2	99.5	99.5
Mn+4	99.5	99.5
Mnp	99.5	99.5
Na+	99.5	99.5
Nap+	99.5	99.5
Ni+2	99.5	99.5
NO2-	99.5	99.5
NO3-	99.5	99.5
OH-	99.5	99.5
Pb+2	99.5	99.5
Pd+2	99.5	99.5
PO4-3	99.5	99.5
Si+4	99.5	99.5
SO4-2	99.5	99.5
Sr+2	99.5	99.5
Ti+4	99.5	99.5
Zn+2	99.5	99.5
Zr+4	99.5	99.5

Table D-9 PJV-HEPA Splits

PJV-HEPA Components	Liquid % to Accumulate	Solid % to Accumulate
125-Sb	99.99994001	99.99994001
126-Sn	99.99994001	99.99994001
134-Cs	99.99994001	99.99994001
137-Cs	99.99994001	99.99994001
151-Sm	99.99994001	99.99994001
152-Eu	99.99994001	99.99994001
154-Eu	99.99994001	99.99994001
155-Eu	99.99994001	99.99994001
232-Th	99.99994001	99.99994001
233-U	99.99994001	99.99994001
234-U	99.99994001	99.99994001

PJV-HEPA Components	Liquid % to Accumulate	Solid % to Accumulate
235-U	99.99994001	99.99994001
236-U	99.99994001	99.99994001
237-Np	99.99994001	99.99994001
238-Pu	99.99994001	99.99994001
238-U	99.99994001	99.99994001
239-Pu	99.99994001	99.99994001
240-Pu	99.99994001	99.99994001
241-Am	99.99994001	99.99994001
241-Pu	99.99994001	99.99994001
243-Cm	99.99994001	99.99994001
244-Cm	99.99994001	99.99994001
60-Co	99.99994001	99.99994001
63-Ni	99.99994001	99.99994001
90-Sr	99.99994001	99.99994001
99-Tc	99.99994001	99.99994001
Ag+	99.99994001	99.99994001
Al(OH) ₃	100	100
Al+3	99.99994001	99.99994001
As+5	99.99994001	99.99994001
B+3	99.99994001	99.99994001
Ba+2	99.99994001	99.99994001
Bi+3	99.99994001	99.99994001
C ₂ O ₄ -2	99.99994001	99.99994001
Ca+2	99.99994001	99.99994001
Cd+2	99.99994001	99.99994001
Ce+3	99.99994001	99.99994001
Cl-	99.99994001	99.99994001
CO ₃ -2	99.99994001	99.99994001
Cr(TOTAL)	99.99994001	99.99994001
Cu+2	99.99994001	99.99994001
F-	99.99994001	99.99994001
Fe+3	99.99994001	99.99994001
K+	99.99994001	99.99994001
La+3	99.99994001	99.99994001
Li+	99.99994001	99.99994001
Mg+2	99.99994001	99.99994001
Mn+4	99.99994001	99.99994001
Mnp	100	100
Na+	100	100
Nap+	100	100
Ni+2	99.99994001	99.99994001
NO ₂ -	99.99994001	99.99994001
NO ₃ -	99.99994001	99.99994001
OH-	99.99994001	99.99994001
Pb+2	99.99994001	99.99994001
Pd+2	99.99994001	99.99994001
PO ₄ -3	99.99994001	99.99994001

PJV-HEPA Components	Liquid % to Accumulate	Solid % to Accumulate
Si+4	99.99994001	99.99994001
SO4-2	99.99994001	99.99994001
Sr+2	99.99994001	99.99994001
Ti+4	99.99994001	99.99994001
Zn+2	99.99994001	99.99994001
Zr+4	99.99994001	99.99994001
Gas Components	Gas % to ACCUMULATE	
CO2	0	

Table D-10 TLP-SEP-00001 Splits

TLP-SEP-00001 Components	Liquid/Solid Fractions to TLP-DMST-00001
113m-Cd	0.0000452
125-Sb	0.00025
126-Sn	0.00025
129-I	0.00231
134-Cs	3.57E-08
137-Cs	3.57E-08
137m-Ba	3.57E-08
14-C	0.00099
151-Sm	2.67E-07
152-Eu	7.09E-07
154-Eu	7.09E-07
155-Eu	7.09E-07
229-Th	0.00099
232-Th	0.00099
232-U	0.00099
233-U	0.00099
234-U	0.00099
235-U	0.00099
236-U	0.00099
237-Np	0.00099
238-Pu	2.67E-07
238-U	0.00099
239-Pu	2.67E-07
240-Pu	2.67E-07
241-Am	7.09E-07
241-Pu	2.67E-07
242-Cm	0.00099
242-Pu	2.67E-07
243-Am	7.09E-07
243-Cm	0.00099
244-Cm	0.00099
3-H	0.5988
59-Ni	0.0000339
60-Co	0.00099

TLP-SEP-00001**Components****Liquid/Solid Fractions
to TLP-DMST-00001**

63-Ni	0.0000339
90-Sr	4.31E-06
90-Y	4.31E-06
93-Zr	0.00099
99-Tc	0.00099
Ag+	0.00099
Al(OH) ₄ ⁻	0.000658
Al ⁺³	0.000658
As ⁺⁵	0.00099
B ⁺³	0.00099
Ba ⁺²	0.00099
Bi ⁺³	0.00025
C ₁₀ H ₁₂ N ₂ O ₈ ⁻⁴	0.001
C ₁₀ H ₁₅ N ₂ O ₇ ⁻³	0.001
C ₁₂ H ₂₇ O ₄ P	0.001
C ₂ O ₄ ⁻²	0.001
C ₆ H ₅ O ₇ ⁻³	0.09346
Ca ⁺²	0.001
Cd ⁺²	0.0000452
Ce ⁺³	0.00099
Cl ⁻	0.0019
Co ⁺³	0.00099
CO ₃ ⁻²	0.00099
Cr(OH) ₄ ⁻	0.0000282
Cr(TOTAL)	0.0000282
Cs ⁺	3.57E-08
Cu ⁺²	0.00099
F ⁻	0.0000411
Fe ⁺³	0.00099
H ⁺	0.1
Hg ⁺²	0.00099
K ⁺	0.000282
La ⁺³	0.00099
Li ⁺	0.000033
Mg ⁺²	0.00099
Mn ⁺⁴	0.00099
MnO ₄ ⁻	0.00099
Na ⁺	0.000033
NH ₃	0.9
Ni ⁺²	0.0000339
NO ₂ ⁻	0.000412
NO ₃ ⁻	0.001733
OH(BOUND)	0.00099
OH ⁻	0.00099
Pb ⁺²	0.00025
Pd ⁺²	0.0000339
PO ₄ ⁻³	0.00099

TLP-SEP-00001 Components	Liquid/Solid Fractions to TLP-DMST-00001
Pu+4	2.67E-07
Sb+5	0.00025
Si+4	0.00099
SO4-2	0.000704
Sr+2	4.31E-06
Tc+7	0.00099
Th+4	0.00099
Ti+4	0.00099
U(TOTAL)	0.00099
Zn+2	0.00099
Zr+4	0.00099
C12H4Cl6	0.0004
C2H3N	0.969
Mnp	0.00099
Nap+	0.000033
Al(OH)3	0.000658
PPG	1.00E-08
DPPG	1.00E-08
PDMS	1.00E-08
DPDMS	1.00E-08

Table D-11 TLP-DMST-00001 Splits

TLP-DMST-00001 Components	Liquid/Solid Fractions to PVP Vessel Vent
113m-Cd	0.00154
125-Sb	0.0000358
126-Sn	0.0000358
129-I	0.0011
134-Cs	0.0000427
137-Cs	0.0000427
137m-Ba	0.0000427
14-C	0.00154
151-Sm	0.00032
152-Eu	0.00032
154-Eu	0.00032
155-Eu	0.00032
229-Th	0.00154
232-Th	0.00154
232-U	0.00154
233-U	0.00154
234-U	0.00154
235-U	0.00154
236-U	0.00154
237-Np	0.00154
238-Pu	0.00032
238-U	0.00154
239-Pu	0.00032

**TLP-DMST-00001
Components****Liquid/Solid Fractions
to PVP Vessel Vent**

240-Pu	0.00032
241-Am	0.00032
241-Pu	0.00032
242-Cm	0.00154
242-Pu	0.00032
243-Am	0.00032
243-Cm	0.00154
244-Cm	0.00154
3-H	0.014
59-Ni	0.00154
60-Co	0.00154
63-Ni	0.00154
90-Sr	0.0000855
90-Y	0.0000855
93-Zr	0.002
99-Tc	0.00154
Ag+	0.00188
Al(OH) ₄ ⁻	0.00154
Al ⁺³	0.00154
As ⁺⁵	0.00154
B ⁺³	0.00177
Ba ⁺²	0.002016
Bi ⁺³	0.0000358
C ₁₀ H ₁₂ N ₂ O ₈ -4	0.05814
C ₁₀ H ₁₅ N ₂ O ₇ -3	0.05814
C ₁₂ H ₂₇ O ₄ P	0.05814
C ₂ O ₄ -2	0.05814
C ₆ H ₅ O ₇ -3	1.53E-06
Ca ⁺²	0.05814
Cd ⁺²	0.00154
Ce ⁺³	0.00154
Cl ⁻	0.0001299
Co ⁺³	0.00154
CO ₃ -2	0.00154
Cr(OH) ₄ ⁻	0.000188
Cr(TOTAL)	0.000188
Cs ⁺	0.0000427
Cu ⁺²	0.00188
F ⁻	0.00053
Fe ⁺³	0.002
H ⁺	0.01
Hg ⁺²	0.00154
K ⁺	0.00157
La ⁺³	0.00154
Li ⁺	0.0016
Mg ⁺²	0.035
Mn ⁺⁴	0.001642

TLP-DMST-00001	Liquid/Solid Fractions
Components	to PVP Vessel Vent
MnO4-	0.001642
Na+	0.002
NH3	0.0806
Ni+2	0.00154
NO2-	0.0000962
NO3-	0.0000962
OH(BOUND)	0.00154
OH-	0.00154
Pb+2	0.0000358
Pd+2	0.00154
PO4-3	0.00154
Pu+4	0.00032
Sb+5	0.0000358
Si+4	0.00435
SO4-2	0.0002375
Sr+2	0.0000855
Tc+7	0.00154
Th+4	0.00154
Ti+4	0.002
U(TOTAL)	0.00154
Zn+2	0.001621
Zr+4	0.002
C12H4Cl6	0.0004
C2H3N	0.8314
Mnp	0.002
Nap+	0.002
Al(OH)3	0.002

Table D-12 LAW Melter Splits

LMP-MLTR-00001/2	Liquid %	Solid %
Components	to LOP-SCB-00001/2	to LOP-SCB-00001/2
106-Ru	1.852	1.852
113m-Cd	0.855	0.855
125-Sb	24.39	24.39
126-Sn	0.943	0.943
129-I	0	0
134-Cs	24.39	24.39
137-Cs	24.39	24.39
137m-Ba	24.39	24.39
14-C	100	100
151-Sm	0.943	0.943
152-Eu	0.943	0.943
154-Eu	0.943	0.943
155-Eu	0.943	0.943
226-Ra	24.39	24.39
227-Ac	0.943	0.943
228-Ra	24.39	24.39

LMP-MLTR-00001/2 Components	Liquid % to LOP-SCB-00001/2	Solid % to LOP-SCB-00001/2
229-Th	0.943	0.943
231-Pa	0.943	0.943
232-Th	0.943	0.943
232-U	0.943	0.943
233-U	0.943	0.943
234-U	0.943	0.943
235-U	0.943	0.943
236-U	0.943	0.943
237-Np	0.943	0.943
238-Pu	0.943	0.943
238-U	0.943	0.943
239-Pu	0.943	0.943
240-Pu	0.943	0.943
241-Am	1.852	1.852
241-Pu	0.943	0.943
242-Cm	0.943	0.943
242-Pu	0.943	0.943
243-Am	1.852	1.852
243-Cm	0.943	0.943
244-Cm	0.943	0.943
3-H	100	100
59-Ni	0.941	0.941
60-Co	0.943	0.943
63-Ni	0.941	0.941
79-Se	24.39	24.39
90-Sr	0.943	0.943
90-Y	0.943	0.943
93-Zr	0.021	0.021
93m-Nb	0.943	0.943
99-Tc	62.5	62.5
Ag+	1.852	1.852
Al(OH)3	0.192	0.192
Al(OH)4-	0.192	0.192
Al+3	0.192	0.192
As+5	24.39	24.39
B+3	1.0604	1.0604
Ba+2	0.943	0.943
Be+2	0.943	0.943
Bi+3	1.852	1.852
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	92.593	92.593
C12H27O4P	0	0
C12H4Cl6	0	0
C12H8	0	0
C13H28	0	0
C2Cl4	0	0

LMP-MLTR-00001/2	Liquid %	Solid %
Components	to LOP-SCB-00001/2	to LOP-SCB-00001/2
C2H3N	0	0
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	0	0
C3H6O	20.04	20.04
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	0.125	0.125
CCl4	0	0
Cd+2	0.855	0.855
Ce+3	0.943	0.943
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	0	0
CN-	1.852	1.852
Co+3	0.943	0.943
CO3-2	0	0
Cr(OH)4-	7.143	7.143
Cr(TOTAL)	7.143	7.143
Cs+	14.286	14.286
Cu+2	9.091	9.091
DPDMS	0	0
DPPG	0	0
F-	0	0
Fe+3	0.185	0.185
H+	0	0
H2CO3	0	0
H2O	0	0
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	0	0
Hg+2	0	0
K+	5	5

LMP-MLTR-00001/2	Liquid %	Solid %
Components	to LOP-SCB-00001/2	to LOP-SCB-00001/2
La+3	0.943	0.943
Li+	0.952	0.952
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	0.016	0.016
Mn+4	0.943	0.943
MnO2	0.943	0.943
MnO4-	0.943	0.943
Mnp	0.943	0.943
Mo+6	1.852	1.852
Na+	1.282	1.282
Nap+	1.282	1.282
Nd+3	0.943	0.943
NH3	0	0
NH4+	0	0
Ni+2	0.943	0.943
NO2-	0	0
NO3-	0	0
NO3-D	0	0
O-2	0	0
OH(BOUND)	0	0
OH-	0	0
Pb+2	1.852	1.852
Pd+2	0.943	0.943
PDMS	0	0
PO4-3	1.19	1.19
PO4-3(HARD)	1.19	1.19
PPG	0	0
Pr+3	0.943	0.943
Pu+4	0.943	0.943
Rb+	1.852	1.852
Rh+3	0.943	0.943
Ru+3	0.943	0.943
Sb+5	24.39	24.39
Se+6	24.39	24.39
Si+4	0.116	0.116
SO4-2	0	0
Sr+2	0.943	0.943
Ta+5	0.943	0.943
Tc+7	62.5	62.5
Te+6	24.39	24.39
Th+4	0.943	0.943
Ti+4	0.294	0.294
Tl+3	24.39	24.39
TOC	0	0
U(TOTAL)	0.943	0.943

LMP-MLTR-00001/2	Liquid %	Solid %
Components	to LOP-SCB-00001/2	to LOP-SCB-00001/2
V+5	1.852	1.852
W+6	0.943	0.943
Y+3	0.943	0.943
Zn+2	0.286	0.286
Zr+4	0.022	0.022

DFs are handled differently in the LAW melters. Refer to Section 4.8.15 for detailed discussions.

Table D-13 LAW SBS Splits

LOP-SCB-00001/2	Liquid %	Solid %
Components	to LOP-VSL-00001/2	to LOP-VSL-00001/2
106-Ru	72.22222222	72.22222222
113m-Cd	81.13207547	81.13207547
125-Sb	99	99
126-Sn	98.82352941	98.82352941
129-I	0	0
134-Cs	79.59183673	79.59183673
137-Cs	79.59183673	79.59183673
137m-Ba	79.59183673	79.59183673
14-C	0	0
151-Sm	98.82352941	98.82352941
152-Eu	98.82352941	98.82352941
154-Eu	98.82352941	98.82352941
155-Eu	98.82352941	98.82352941
226-Ra	98.82352941	98.82352941
227-Ac	98.82352941	98.82352941
228-Ra	98.82352941	98.82352941
229-Th	98.82352941	98.82352941
231-Pa	98.82352941	98.82352941
232-Th	98.82352941	98.82352941
232-U	98.82352941	98.82352941
233-U	98.82352941	98.82352941
234-U	98.82352941	98.82352941
235-U	98.82352941	98.82352941
236-U	98.82352941	98.82352941
237-Np	98.82352941	98.82352941
238-Pu	98.82352941	98.82352941
238-U	98.82352941	98.82352941
239-Pu	98.82352941	98.82352941
240-Pu	98.82352941	98.82352941
241-Am	98.82352941	98.82352941
241-Pu	98.82352941	98.82352941
242-Cm	98.82352941	98.82352941
242-Pu	98.82352941	98.82352941
243-Am	98.82352941	98.82352941
243-Cm	98.82352941	98.82352941
244-Cm	98.82352941	98.82352941

LOP-SCB-00001/2 Components	Liquid % to LOP-VSL-00001/2	Solid % to LOP-VSL-00001/2
3-H	0	0
59-Ni	75	75
60-Co	89.36170213	89.36170213
63-Ni	75	75
79-Se	88.0952381	88.0952381
90-Sr	99.851	99.851
90-Y	99.851	99.851
93-Zr	96.552	96.552
93m-Nb	98.82352941	98.82352941
99-Tc	79.59183673	79.59183673
Ag+	98	98
Al(OH)3	99.04761905	99.04761905
Al(OH)4-	99.04761905	99.04761905
Al+3	99.04761905	99.04761905
AlOOH	0	0
As+5	95	95
B+3	56.522	56.522
Ba+2	99.71428571	99.71428571
Be+2	98.82352941	98.82352941
Bi+3	98	98
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	0	0
C12H27O4P	0	0
C12H4Cl6	94.50549451	94.50549451
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	94.50549451	94.50549451
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	87.95180723	87.95180723
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0

LOP-SCB-00001/2	Liquid %	Solid %
Components	to LOP-VSL-00001/2	to LOP-VSL-00001/2
C8H8O	0	0
Ca+2	97.76785714	97.76785714
CCl4	0	0
Cd+2	81.13207547	81.13207547
Ce+3	99.83870968	99.83870968
CH2Cl2	0	0
CHCl3	0	0
CHO2-	87.95180723	87.95180723
Cl-	87.95180723	87.95180723
CN-	87.95180723	87.95180723
Co+3	89.36170213	89.36170213
CO3-2	87.95180723	87.95180723
Cr(OH)4-	82.75862069	82.75862069
Cr(TOTAL)	82.75862069	82.75862069
Cs+	79.59183673	79.59183673
Cu+2	99.28571429	99.28571429
DPDMS	0	0
DPPG	0	0
F-	85.915	85.915
Fe+3	99.091	99.091
H+	99.9	99.9
H2CO3	0	0
H2O	0	0
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	87.95180723	87.95180723
Hg+2	0	0
K+	81.13207547	81.13207547
La+3	99.9	99.9
Li+	88.23529412	88.23529412
LS10	0	0
LS9	0	0
Mg+2	87.342	87.342
Mn+4	99.88235294	99.88235294
MnO2	99.88235294	99.88235294
MnO4-	99.88235294	99.88235294
Mnp	99.88235294	99.88235294
Mo+6	88.50574713	88.50574713
Na+	87.95180723	87.95180723
Nap+	87.95180723	87.95180723
Nd+3	99.9	99.9
NH3	90	90
NH4+	90	90
Ni+2	75	75
NO2-	0.199600798	0.199600798
NO3-	87.95180723	87.95180723
NO3-D	0	0

LOP-SCB-00001/2 Components	Liquid % to LOP-VSL-00001/2	Solid % to LOP-VSL-00001/2
O-2	0	0
OH(BOUND)	87.95180723	87.95180723
OH-	87.95180723	87.95180723
Pb+2	86.84210526	86.84210526
Pd+2	98.82352941	98.82352941
PDMS	0	0
PO4-3	60	60
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	98.82352941	98.82352941
Pu+4	98.82352941	98.82352941
Rb+	79.59183673	79.59183673
Rh+3	79.59183673	79.59183673
Ru+3	72.22222222	72.22222222
Sb+5	99	99
Se+6	88.0952381	88.0952381
Si+4	99.07407407	99.07407407
SO4-2	85.71428571	85.71428571
Sr+2	99.85074627	99.85074627
Ta+5	98.82352941	98.82352941
Tc+7	79.59183673	79.59183673
Te+6	95	95
Th+4	98.82352941	98.82352941
Ti+4	99.643	99.643
Tl+3	88.0952381	88.0952381
TOC	0	0
U(TOTAL)	98.82352941	98.82352941
V+5	82.45614035	82.45614035
W+6	98.82352941	98.82352941
Y+3	99.6875	99.6875
Zn+2	96.62162162	96.62162162
Zr+4	96.552	96.552

Table D-14 LAW WESP Splits

LOP-WESP-00001/2 Components	Liquid % to RLD-VSL-00004	Solid % to RLD-VSL-00004
106-Ru	99.9	99.9
113m-Cd	99.9	99.9
125-Sb	99.9	99.9
126-Sn	99.9	99.9
129-I	0	0
134-Cs	96	96
137-Cs	96	96
137m-Ba	96	96
14-C	0	0
151-Sm	98	98
152-Eu	99.9	99.9

LOP-WESP-00001/2 Components	Liquid % to RLD-VSL-00004	Solid % to RLD-VSL-00004
154-Eu	99.9	99.9
155-Eu	99.9	99.9
226-Ra	99.9	99.9
227-Ac	99.9	99.9
228-Ra	99.9	99.9
229-Th	99.9	99.9
231-Pa	98	98
232-Th	99.9	99.9
232-U	99.9	99.9
233-U	99.9	99.9
234-U	99.9	99.9
235-U	99.9	99.9
236-U	99.9	99.9
237-Np	99.9	99.9
238-Pu	99.9	99.9
238-U	99.9	99.9
239-Pu	99.9	99.9
240-Pu	99.9	99.9
241-Am	99.9	99.9
241-Pu	99.9	99.9
242-Cm	99.9	99.9
242-Pu	99.9	99.9
243-Am	99.9	99.9
243-Cm	99.9	99.9
244-Cm	99.9	99.9
3-H	0	0
59-Ni	99.9	99.9
60-Co	99.9	99.9
63-Ni	99.9	99.9
79-Se	99.9	99.9
90-Sr	99.9	99.9
90-Y	99.9	99.9
93-Zr	33.333	33.333
93m-Nb	98	98
99-Tc	99.9	99.9
Ag+	99.9	99.9
Al(OH) ₃	99.9	99.9
Al(OH) ₄ ⁻	99.9	99.9
Al ⁺³	79.167	79.167
As ⁺⁵	99.9	99.9
B ⁺³	56.522	56.522
Ba ⁺²	99.9	99.9
Be ⁺²	99.9	99.9
Bi ⁺³	99.9	99.9
C ₁₀ H ₁₂ N ₂ O ₈ -4	0	0
C ₁₀ H ₁₅ N ₂ O ₇ -3	0	0
C ₁₀ H ₈	0	0

LOP-WESP-00001/2	Liquid %	Solid %
Components	to RLD-VSL-00004	to RLD-VSL-00004
C12H27O4P	0	0
C12H4Cl6	99.796	99.796
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	99.796	99.796
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	99.796	99.796
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	85.714	85.714
CCl4	0	0
Cd+2	96.296	96.296
Ce+3	99.9	99.9
CH2Cl2	0	0
CHCl3	0	0
CHO2-	99.796	99.796
Cl-	58.333	58.333
CN-	96.296	96.296
Co+3	99.9	99.9
CO3-2	96.296	96.296
Cr(OH)4-	88.764	88.764
Cr(TOTAL)	88.764	88.764
Cs+	96.154	96.154
Cu+2	99.9	99.9
DPDMS	0	0
DPPG	0	0
F-	76.19	76.19
Fe+3	88.636	88.636
H+	0	0
H2CO3	0	0
H2O	99.9	99.9

LOP-WESP-00001/2 Components	Liquid % to RLD-VSL-00004	Solid % to RLD-VSL-00004
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	96.296	96.296
Hg+2	0	0
K+	96.667	96.667
La+3	99.9	99.9
Li+	94.737	94.737
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	56.522	56.522
Mn+4	99.9	99.9
MnO2	99.9	99.9
MnO4-	99.9	99.9
Mnp	99.9	99.9
Mo+6	99.9	99.9
Na+	96.296	96.296
Nap+	96.296	96.296
Nd+3	99.9	99.9
NH3	23.077	23.077
NH4+	99.9	99.9
Ni+2	99.9	99.9
NO2-	3.846	3.846
NO3-	96.296	96.296
NO3-D	0	0
O-2	0	0
OH(BOUND)	99.9	99.9
OH-	99.9	99.9
Pb+2	93.333	93.333
Pd+2	99.9	99.9
PDMS	0	0
PO4-3	83.051	83.051
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	99.9	99.9
Pu+4	99.9	99.9
Rb+	99.9	99.9
Rh+3	99.9	99.9
Ru+3	99.9	99.9
Sb+5	99.9	99.9
Se+6	99.9	99.9
Si+4	88.889	88.889
SO4-2	91.667	91.667
Sr+2	99.9	99.9
Ta+5	99.9	99.9
Tc+7	99.9	99.9
Te+6	99.9	99.9

LOP-WESP-00001/2 Components	Liquid % to RLD-VSL-00004	Solid % to RLD-VSL-00004
Th+4	99.9	99.9
Ti+4	16.667	16.667
Tl+3	99.9	99.9
TOC	0	0
U(TOTAL)	99.9	99.9
V+5	99.9	99.9
W+6	99.9	99.9
Y+3	99.9	99.9
Zn+2	71.429	71.429
Zr+4	33.333	33.333

Table D-15 LAW HEPA Splits

LVP-HEPA-00001AB Components	Liquid % to Accumulate	Solid % to Accumulate
106-Ru	99.99994	99.99994
113m-Cd	99.99994	99.99994
125-Sb	99.99994	99.99994
126-Sn	99.99994	99.99994
129-I	0	0
134-Cs	99.99994	99.99994
137-Cs	99.99994	99.99994
137m-Ba	99.99994	99.99994
14-C	0	0
151-Sm	99.99994	99.99994
152-Eu	99.99994	99.99994
154-Eu	99.99994	99.99994
155-Eu	99.99994	99.99994
226-Ra	99.99994	99.99994
227-Ac	99.99994	99.99994
228-Ra	99.99994	99.99994
229-Th	99.99994	99.99994
231-Pa	99.99994	99.99994
232-Th	99.99994	99.99994
232-U	99.99994	99.99994
233-U	99.99994	99.99994
234-U	99.99994	99.99994
235-U	99.99994	99.99994
236-U	99.99994	99.99994
237-Np	99.99994	99.99994
238-Pu	99.99994	99.99994
238-U	99.99994	99.99994
239-Pu	99.99994	99.99994
240-Pu	99.99994	99.99994
241-Am	99.99994	99.99994
241-Pu	99.99994	99.99994
242-Cm	99.99994	99.99994
242-Pu	99.99994	99.99994

LVP-HEPA-00001AB**Components****Liquid %
to Accumulate****Solid %
to Accumulate**

243-Am	99.99994	99.99994
243-Cm	99.99994	99.99994
244-Cm	99.99994	99.99994
3-H	0	0
59-Ni	99.99994	99.99994
60-Co	99.99994	99.99994
63-Ni	99.99994	99.99994
79-Se	99.99994	99.99994
90-Sr	99.99994	99.99994
90-Y	99.99994	99.99994
93-Zr	99.99994	99.99994
93m-Nb	99.99994	99.99994
99-Tc	99.99994	99.99994
Ag+	99.99994	99.99994
Al(OH)3	99.99994	99.99994
Al(OH)4-	99.99994	99.99994
Al+3	99.99994	99.99994
As+5	99.99994	99.99994
B+3	99.97	99.97
Ba+2	99.99994	99.99994
Be+2	99.99994	99.99994
Bi+3	99.99994	99.99994
C10H12N2O8-4	99.99994	99.99994
C10H15N2O7-3	99.99994	99.99994
C10H8	99.99994	99.99994
C12H27O4P	99.99994	99.99994
C12H4Cl6	99.99994	99.99994
C12H8	99.99994	99.99994
C13H28	99.99994	99.99994
C2Cl4	99.99994	99.99994
C2H3N	99.99994	99.99994
C2H3O2-	99.99994	99.99994
C2H3O3-	99.99994	99.99994
C2H6SiO	99.99994	99.99994
C2H8N2	99.99994	99.99994
C2HCl3	99.99994	99.99994
C2O4-2	99.99994	99.99994
C3H6O	99.99994	99.99994
C4H10O	99.99994	99.99994
C4H7NO4	99.99994	99.99994
C4H8O	99.99994	99.99994
C5H5N	99.99994	99.99994
C6H5NO2	99.99994	99.99994
C6H5O7-3	99.99994	99.99994
C6H6	99.99994	99.99994
C6H6O	99.99994	99.99994
C7H6N2O4	99.99994	99.99994

LVP-HEPA-00001AB

Components

**Liquid %
to Accumulate**

**Solid %
to Accumulate**

C7H8	99.99994	99.99994
C7H8O	99.99994	99.99994
C8H8O	99.99994	99.99994
Ca+2	99.99994	99.99994
CCl4	99.99994	99.99994
Cd+2	99.99994	99.99994
Ce+3	99.99994	99.99994
CH2Cl2	99.99994	99.99994
CHCl3	99.99994	99.99994
CHO2-	99.99994	99.99994
Cl-	99.99994	99.99994
CN-	99.99994	99.99994
Co+3	99.99994	99.99994
CO3-2	99.99994	99.99994
Cr(OH)4-	99.99994	99.99994
Cr(TOTAL)	99.99994	99.99994
Cs+	99.99994	99.99994
Cu+2	99.99994	99.99994
DPDMS	99.99994	99.99994
DPPG	99.99994	99.99994
F-	99.99994	99.99994
Fe+3	99.99994	99.99994
H+	99.99994	99.99994
H2CO3	99.99994	99.99994
H2O	0	0
H2O(BOUND)	99.99994	99.99994
H2O2	99.99994	99.99994
HCO3-	99.99994	99.99994
Hg+2	0	0
K+	99.99994	99.99994
La+3	99.99994	99.99994
Li+	99.99994	99.99994
LS10	99.99994	99.99994
AlOOH	99.99994	99.99994
LS9	99.99994	99.99994
Mg+2	99.99994	99.99994
Mn+4	99.99994	99.99994
MnO2	99.99994	99.99994
MnO4-	99.99994	99.99994
Mnp	99.99994	99.99994
Mo+6	99.99994	99.99994
Na+	99.99994	99.99994
Nap+	99.99994	99.99994
Nd+3	99.99994	99.99994
NH3	99.99994	99.99994
NH4+	99.99994	99.99994
Ni+2	99.99994	99.99994

LVP-HEPA-00001AB**Components****Liquid %
to Accumulate****Solid %
to Accumulate**

NO2-	0	0
NO3-	99.99994	99.99994
NO3-D	99.99994	99.99994
O-2	99.99994	99.99994
OH(BOUND)	99.99994	99.99994
OH-	99.99994	99.99994
Pb+2	99.99994	99.99994
Pd+2	99.99994	99.99994
PDMS	99.99994	99.99994
PO4-3	99.99994	99.99994
PO4-3(HARD)	99.99994	99.99994
PPG	99.99994	99.99994
Pr+3	99.99994	99.99994
Pu+4	99.99994	99.99994
Rb+	99.99994	99.99994
Rh+3	99.99994	99.99994
Ru+3	99.99994	99.99994
Sb+5	99.99994	99.99994
Se+6	99.99994	99.99994
Si+4	99.99994	99.99994
SO4-2	99.99994	99.99994
Sr+2	99.99994	99.99994
Ta+5	99.99994	99.99994
Tc+7	99.99994	99.99994
Te+6	99.99994	99.99994
Th+4	99.99994	99.99994
Ti+4	99.99994	99.99994
Tl+3	99.99994	99.99994
TOC	99.99994	99.99994
U(TOTAL)	99.99994	99.99994
V+5	99.99994	99.99994
W+6	99.99994	99.99994
Y+3	99.99994	99.99994
Zn+2	99.99994	99.99994
Zr+4	99.99994	99.99994

Gas %**Gas Components****to ACCUMULATE**

129-I	0
C12H4Cl6	99.99994
C2H3N	99.99994
CO2	0
H2O	0
HCl	69.512
HF	26.471
Hg	99.99994
N2	0
NH3	99.99994
NO	0

LVP-HEPA-00001AB	Liquid %	Solid %
Components	to Accumulate	to Accumulate
NO2	0	
O2	0	
P2O5	99.99994	
SO2	90	
SO3	99.99994	

Table D-16 LAW Carbon Absorber Splits

LVP-ADBR-00001AB	Liquid %	Solid %
Components	to Accumulate	to Accumulate
106-Ru	0	0
113m-Cd	0	0
125-Sb	0	0
126-Sn	0	0
129-I	0	0
134-Cs	0	0
137-Cs	0	0
137m-Ba	0	0
14-C	0	0
151-Sm	0	0
152-Eu	0	0
154-Eu	0	0
155-Eu	0	0
226-Ra	0	0
227-Ac	0	0
228-Ra	0	0
229-Th	0	0
231-Pa	0	0
232-Th	0	0
232-U	0	0
233-U	0	0
234-U	0	0
235-U	0	0
236-U	0	0
237-Np	0	0
238-Pu	0	0
238-U	0	0
239-Pu	0	0
240-Pu	0	0
241-Am	0	0
241-Pu	0	0
242-Cm	0	0
242-Pu	0	0
243-Am	0	0
243-Cm	0	0
244-Cm	0	0
3-H	0	0
59-Ni	0	0

LVP-ADBR-00001AB**Components****Liquid %
to Accumulate****Solid %
to Accumulate**

60-Co	0	0
63-Ni	0	0
79-Se	0	0
90-Sr	0	0
90-Y	0	0
93-Zr	0	0
93m-Nb	0	0
99-Tc	0	0
Ag+	0	0
Al(OH)3	0	0
Al(OH)4-	0	0
Al+3	0	0
As+5	0	0
B+3	0	0
Ba+2	0	0
Be+2	0	0
Bi+3	0	0
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	0	0
C12H27O4P	0	0
C12H4Cl6	0	0
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	0	0
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	0	0
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	0	0
CCl4	0	0

LVP-ADBR-00001AB		
Components	Liquid % to Accumulate	Solid % to Accumulate
Cd+2	0	0
Ce+3	0	0
CH ₂ Cl ₂	0	0
CHCl ₃	0	0
CHO ₂ -	0	0
Cl-	0	0
CN-	0	0
Co+3	0	0
CO ₃ -2	0	0
Cr(OH) ₄ -	0	0
Cr(TOTAL)	0	0
Cs+	0	0
Cu+2	0	0
DPDMS	0	0
DPPG	0	0
F-	0	0
Fe+3	0	0
H+	0	0
H ₂ CO ₃	0	0
H ₂ O	0	0
H ₂ O(BOUND)	0	0
H ₂ O ₂	0	0
HCO ₃ -	0	0
Hg+2	0	0
K+	0	0
La+3	0	0
Li+	0	0
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	0	0
Mn+4	0	0
MnO ₂	0	0
MnO ₄ -	0	0
Mnp	0	0
Mo+6	0	0
Na+	0	0
Nap+	0	0
Nd+3	0	0
NH ₃	0	0
NH ₄ +	0	0
Ni+2	0	0
NO ₂ -	0	0
NO ₃ -	0	0
NO ₃ -D	0	0
O-2	0	0
OH(BOUND)	0	0

LVP-ADBR-00001AB

Components

**Liquid %
to Accumulate**

**Solid %
to Accumulate**

OH-	0	0
Pb+2	0	0
Pd+2	0	0
PDMS	0	0
PO4-3	0	0
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	0	0
Pu+4	0	0
Rb+	0	0
Rh+3	0	0
Ru+3	0	0
Sb+5	0	0
Se+6	0	0
Si+4	0	0
SO4-2	0	0
Sr+2	0	0
Ta+5	0	0
Tc+7	0	0
Te+6	0	0
Th+4	0	0
Ti+4	0	0
Tl+3	0	0
TOC	0	0
U(TOTAL)	0	0
V+5	0	0
W+6	0	0
Y+3	0	0
Zn+2	0	0
Zr+4	0	0

**Gas %
to ACCUMULATE**

Gas Components

129-I	99
C12H4Cl6	0
C2H3N	0
CO2	0
H2O	0
HCl	96.997
HF	96.997
Hg	99.583
N2	0
NH3	0
NO	0
NO2	0
O2	0
P2O5	0
SO2	0
SO3	0

Table D-17 LAW Catalytic-Oxidizer-Reducer Splits

LVP-SCR-00001-2	Liquid %	Solid %
Components	to Accumulate	to Accumulate
C2O4-2	99.999	99.999
	Gas %	
Gas Components	to Accumulate	
NO	0	
NO2	0	

Table D-18 LAW Caustic Scrubber Splits

LVP-SCB-00001	Liquid %	Solid %
Components	to LVP-TK-00001	to LVP-TK-00001
106-Ru	0	0
113m-Cd	0	0
125-Sb	0	0
126-Sn	0	0
129-I	0	0
134-Cs	0	0
137-Cs	0	0
137m-Ba	0	0
14-C	0	0
151-Sm	0	0
152-Eu	0	0
154-Eu	0	0
155-Eu	0	0
226-Ra	0	0
227-Ac	0	0
228-Ra	0	0
229-Th	0	0
231-Pa	0	0
232-Th	0	0
232-U	0	0
233-U	0	0
234-U	0	0
235-U	0	0
236-U	0	0
237-Np	0	0
238-Pu	0	0
238-U	0	0
239-Pu	0	0
240-Pu	0	0
241-Am	0	0
241-Pu	0	0
242-Cm	0	0
242-Pu	0	0
243-Am	0	0
243-Cm	0	0
244-Cm	0	0

LVP-SCB-00001	Liquid %	Solid %
Components	to LVP-TK-00001	to LVP-TK-00001
3-H	0	0
59-Ni	0	0
60-Co	0	0
63-Ni	0	0
79-Se	0	0
90-Sr	0	0
90-Y	0	0
93-Zr	0	0
93m-Nb	0	0
99-Tc	0	0
Ag+	0	0
Al(OH) ₃	0	0
Al(OH) ₄ ⁻	0	0
Al ³⁺	0	0
As ⁵⁺	0	0
B ³⁺	0	0
Ba ²⁺	0	0
Be ²⁺	0	0
Bi ³⁺	0	0
C ₁₀ H ₁₂ N ₂ O ₈ -4	0	0
C ₁₀ H ₁₅ N ₂ O ₇ -3	0	0
C ₁₀ H ₈	0	0
C ₁₂ H ₂₇ O ₄ P	0	0
C ₁₂ H ₄ Cl ₆	0	0
C ₁₂ H ₈	0	0
C ₁₃ H ₂₈	0	0
C ₂ Cl ₄	0	0
C ₂ H ₃ N	0	0
C ₂ H ₃ O ₂ ⁻	0	0
C ₂ H ₃ O ₃ ⁻	0	0
C ₂ H ₆ SiO	0	0
C ₂ H ₈ N ₂	0	0
C ₂ HCl ₃	0	0
C ₂ O ₄ -2	0	0
C ₃ H ₆ O	0	0
C ₄ H ₁₀ O	0	0
C ₄ H ₇ NO ₄	0	0
C ₄ H ₈ O	0	0
C ₅ H ₅ N	0	0
C ₆ H ₅ NO ₂	0	0
C ₆ H ₅ O ₇ -3	0	0
C ₆ H ₆	0	0
C ₆ H ₆ O	0	0
C ₇ H ₆ N ₂ O ₄	0	0
C ₇ H ₈	0	0
C ₇ H ₈ O	0	0
C ₈ H ₈ O	0	0

LVP-SCB-00001	Liquid %	Solid %
Components	to LVP-TK-00001	to LVP-TK-00001
Ca+2	0	0
CCl4	0	0
Cd+2	0	0
Ce+3	0	0
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	0	0
CN-	0	0
Co+3	0	0
CO3-2	0	0
Cr(OH)4-	0	0
Cr(TOTAL)	0	0
Cs+	0	0
Cu+2	0	0
DPDMS	0	0
DPPG	0	0
F-	0	0
Fe+3	0	0
H+	0	0
H2CO3	0	0
H2O	99.99	99.99
H2O2	0	0
HCO3-	0	0
Hg+2	0	0
K+	0	0
La+3	0	0
Li+	0	0
H2O(BOUND)	0	0
LS10	0	0
NO3-D	0	0
AlOOH	0	0
LS9	0	0
Mg+2	0	0
Mn+4	0	0
MnO2	0	0
MnO4-	0	0
Mnp	0	0
Mo+6	0	0
Na+	0	0
Nap+	0	0
Nd+3	0	0
NH3	0	0
NH4+	0	0
Ni+2	0	0
NO2-	0	0
NO3-	0	0

LVP-SCB-00001	Liquid %	Solid %
Components	to LVP-TK-00001	to LVP-TK-00001
O-2	0	0
OH(BOUND)	0	0
OH-	0	0
Pb+2	0	0
Pd+2	0	0
PDMS	0	0
PO4-3	0	0
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	0	0
Pu+4	0	0
Rb+	0	0
Rh+3	0	0
Ru+3	0	0
Sb+5	9.091	9.091
Se+6	0	0
Si+4	0	0
SO4-2	0	0
Sr+2	0	0
Ta+5	0	0
Tc+7	0	0
Te+6	0	0
Th+4	0	0
Ti+4	0	0
Tl+3	0	0
TOC	0	0
U(TOTAL)	0	0
V+5	0	0
W+6	0	0
Y+3	0	0
Zn+2	0	0
Zr+4	0	0

Table D-19 HLW Melter Splits

HMP-MLTR-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
106-Ru	24.39	24.39
113m-Cd	7.692	7.692
125-Sb	0.37	0.37
126-Sn	1.282	1.282
129-I	0	0
134-Cs	2.128	2.128
137-Cs	2.128	2.128
137m-Ba	0.943	0.943
14-C	100	100
151-Sm	1.282	1.282
152-Eu	1.282	1.282

HMP-MLTR-00001/2 Components	Liquid % to HOP-SCB-00001/2	Solid % to HOP-SCB-00001/2
154-Eu	1.282	1.282
155-Eu	1.282	1.282
226-Ra	25.641	25.641
227-Ac	1.282	1.282
228-Ra	25.641	25.641
229-Th	1.282	1.282
231-Pa	1.282	1.282
232-Th	1.282	1.282
232-U	1.282	1.282
233-U	1.282	1.282
234-U	1.282	1.282
235-U	1.282	1.282
236-U	1.282	1.282
237-Np	1.282	1.282
238-Pu	1.282	1.282
238-U	1.282	1.282
239-Pu	1.282	1.282
240-Pu	1.282	1.282
241-Am	1.961	1.961
241-Pu	1.282	1.282
242-Cm	1.282	1.282
242-Pu	1.282	1.282
243-Am	1.961	1.961
243-Cm	1.282	1.282
244-Cm	1.282	1.282
3-H	100	100
59-Ni	0.847	0.847
60-Co	1.282	1.282
63-Ni	0.847	0.847
79-Se	50	50
90-Sr	1.111	1.111
90-Y	0.137	0.137
93-Zr	0.599	0.599
93m-Nb	1.282	1.282
99-Tc	62.5	62.5
Ag+	0.8	0.8
Al(OH) ₃	0.769	0.769
Al(OH) ₄ ⁻	0.769	0.769
Al ⁺³	0.769	0.769
As ⁺⁵	1.852	1.852
B ⁺³	2.0284	2.0284
Ba ⁺²	0.943	0.943
Be ⁺²	1.282	1.282
Bi ⁺³	0.37	0.37
C ₁₀ H ₁₂ N ₂ O ₈ -4	0	0
C ₁₀ H ₁₅ N ₂ O ₇ -3	0	0
C ₁₀ H ₈	95.147	95.147

HMP-MLTR-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
C12H27O4P	0	0
C12H4Cl6	0	0
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	0	0
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	0	0
C3H6O	62.893	62.893
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	1.163	1.163
CCl4	0	0
Cd+2	0.781	0.781
Ce+3	1.282	1.282
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	0	0
CN-	1.961	1.961
Co+3	1.282	1.282
CO3-2	0	0
Cr(OH)4-	1.282	1.282
Cr(TOTAL)	1.282	1.282
Cs+	2.128	2.128
Cu+2	0.8	0.8
DPDMS	0	0
DPPG	0	0
F-	0	0
Fe+3	0.99	0.99
H+	0	0
H2CO3	0	0
H2O	0	0

HMP-MLTR-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	0	0
Hg+2	0	0
K+	3.125	3.125
La+3	1.282	1.282
Li+	0.49	0.49
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	1.786	1.786
Mn+4	0.483	0.483
MnO2	0.483	0.483
MnO4-	0.483	0.483
Mnp	0.483	0.483
Mo+6	1.667	1.667
Na+	0.99	0.99
Nap+	0.99	0.99
Nd+3	1.282	1.282
NH3	0	0
NH4+	0	0
Ni+2	0.847	0.847
NO2-	0	0
NO3-	0	0
NO3-D	0	0
O-2	0	0
OH(BOUND)	0	0
OH-	0	0
Pb+2	1.587	1.587
Pd+2	1.282	1.282
PDMS	0	0
PO4-3	1.053	1.053
PO4-3(HARD)	1.053	1.053
PPG	0	0
Pr+3	1.282	1.282
Pu+4	1.282	1.282
Rb+	1.961	1.961
Rh+3	1.282	1.282
Ru+3	24.39	24.39
Sb+5	0.37	0.37
Se+6	50	50
Si+4	0.455	0.455
SO4-2	0	0
Sr+2	1.111	1.111
Ta+5	1.282	1.282
Tc+7	62.5	62.5
Te+6	7.143	7.143

HMP-MLTR-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
Th+4	1.282	1.282
Ti+4	0.313	0.313
Tl+3	25.641	25.641
TOC	0	0
U(TOTAL)	1.282	1.282
V+5	1.961	1.961
W+6	1.282	1.282
Y+3	0.137	0.137
Zn+2	0.935	0.935
Zr+4	0.599	0.599

Table D-20 HLW SBS Splits

HOP-SCB-00001/2	Liquid %	Solid %
Components	to HOP-VSL-00903/904	to HOP-VSL-00903/904
106-Ru	65.517	65.517
113m-Cd	90.991	90.991
125-Sb	94.764	94.764
126-Sn	98	98
129-I	0	0
134-Cs	69.697	69.697
137-Cs	69.697	69.697
137m-Ba	69.697	69.697
14-C	0.1	0.1
151-Sm	98	98
152-Eu	98	98
154-Eu	98	98
155-Eu	98	98
226-Ra	98	98
227-Ac	98	98
228-Ra	98	98
229-Th	98	98
231-Pa	98	98
232-Th	98	98
232-U	98	98
233-U	98	98
234-U	98	98
235-U	98	98
236-U	98	98
237-Np	98	98
238-Pu	98	98
238-U	98	98
239-Pu	98	98
240-Pu	98	98
241-Am	98	98
241-Pu	98	98
242-Cm	98	98
242-Pu	98	98

HOP-SCB-00001/2	Liquid %	Solid %
Components	to HOP-VSL-00903/904	to HOP-VSL-00903/904
243-Am	98	98
243-Cm	98	98
244-Cm	98	98
3-H	0	0
59-Ni	98.957	98.957
60-Co	88.506	88.506
63-Ni	98.957	98.957
79-Se	79.167	79.167
90-Sr	97.11	97.11
90-Y	97.11	97.11
93-Zr	99.311	99.311
93m-Nb	98	98
99-Tc	98	98
Ag+	98	98
Al(OH) ₃	99.552	99.552
Al(OH) ₄ -	99.552	99.552
Al ⁺³	99.552	99.552
As ⁺⁵	81.132	81.132
B ⁺³	98.953	98.953
Ba ⁺²	90.654	90.654
Be ⁺²	98	98
Bi ⁺³	98	98
C ₁₀ H ₁₂ N ₂ O ₈ -4	0	0
C ₁₀ H ₁₅ N ₂ O ₇ -3	0	0
C ₁₀ H ₈	0	0
C ₁₂ H ₂₇ O ₄ P	0	0
C ₁₂ H ₄ Cl ₆	94.505	94.505
C ₁₂ H ₈	0	0
C ₁₃ H ₂₈	0	0
C ₂ Cl ₄	0	0
C ₂ H ₃ N	94.505	94.505
C ₂ H ₃ O ₂ -	0	0
C ₂ H ₃ O ₃ -	0	0
C ₂ H ₆ SiO	0	0
C ₂ H ₈ N ₂	0	0
C ₂ HCl ₃	0	0
C ₂ O ₄ -2	94.505	94.505
C ₃ H ₆ O	0	0
C ₄ H ₁₀ O	0	0
C ₄ H ₇ NO ₄	0	0
C ₄ H ₈ O	0	0
C ₅ H ₅ N	0	0
C ₆ H ₅ NO ₂	0	0
C ₆ H ₅ O ₇ -3	0	0
C ₆ H ₆	0	0
C ₆ H ₆ O	0	0
C ₇ H ₆ N ₂ O ₄	0	0

HOP-SCB-00001/2	Liquid %	Solid %
Components	to HOP-VSL-00903/904	to HOP-VSL-00903/904
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	97.199	97.199
CCl4	0	0
Cd+2	90.991	90.991
Ce+3	99.808	99.808
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	75.61	75.61
CN-	93.631	93.631
Co+3	88.506	88.506
CO3-2	93.631	93.631
Cr(OH)4-	81.818	81.818
Cr(TOTAL)	81.818	81.818
Cs+	69.697	69.697
Cu+2	92.248	92.248
DPDMS	0	0
DPPG	0	0
F-	98.246	98.246
Fe+3	99.66	99.66
H+	99.95	99.95
H2CO3	93.631	93.631
H2O	0	0
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	93.631	93.631
Hg+2	0	0
K+	88.889	88.889
La+3	99.9	99.9
Li+	94.975	94.975
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	99.057	99.057
Mn+4	98.054	98.054
MnO2	98.054	98.054
MnO4-	98.054	98.054
Mnp	98.054	98.054
Mo+6	90	90
Na+	93.631	93.631
Nap+	93.631	93.631
Nd+3	99.882	99.882
NH3	90	90
NH4+	90	90
Ni+2	98.957	98.957

HOP-SCB-00001/2	Liquid %	Solid %
Components	to HOP-VSL-00903/904	to HOP-VSL-00903/904
NO2-	93.631	93.631
NO3-	93.631	93.631
NO3-D	0	0
O-2	0	0
OH(BOUND)	93.631	93.631
OH-	93.631	93.631
Pb+2	89.362	89.362
Pd+2	98	98
PDMS	0	0
PO4-3	88.235	88.235
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	98	98
Pu+4	98	98
Rb+	98	98
Rh+3	98	98
Ru+3	65.517	65.517
Sb+5	94.764	94.764
Se+6	79.167	79.167
Si+4	99.615	99.615
SO4-2	74.359	74.359
Sr+2	97.11	97.11
Ta+5	98	98
Tc+7	98	98
Te+6	72.222	72.222
Th+4	98	98
Ti+4	96.951	96.951
Tl+3	98	98
TOC	0	0
U(TOTAL)	98	98
V+5	81.132	81.132
W+6	98	98
Y+3	99.643	99.643
Zn+2	98.851	98.851
Zr+4	99.311	99.311

Table D-21 HLW WESP Splits

HOP-WESP-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
106-Ru	95.4954955	95.4954955
113m-Cd	79.16666667	79.16666667
125-Sb	82.45614035	82.45614035
126-Sn	99.9	99.9
129-I	0	0
134-Cs	94.56521739	94.56521739
137-Cs	94.56521739	94.56521739
137m-Ba	94.56521739	94.56521739

HOP-WESP-00001/2 Components	Liquid % to HOP-SCB-00001/2	Solid % to HOP-SCB-00001/2
14-C	0	0
151-Sm	99.9	99.9
152-Eu	99.9	99.9
154-Eu	99.9	99.9
155-Eu	99.9	99.9
226-Ra	99.9	99.9
227-Ac	99.9	99.9
228-Ra	99.9	99.9
229-Th	99.9	99.9
231-Pa	99.9	99.9
232-Th	99.9	99.9
232-U	99.9	99.9
233-U	99.9	99.9
234-U	99.9	99.9
235-U	99.9	99.9
236-U	99.9	99.9
237-Np	99.9	99.9
238-Pu	99.9	99.9
238-U	99.9	99.9
239-Pu	99.9	99.9
240-Pu	99.9	99.9
241-Am	99.9	99.9
241-Pu	99.9	99.9
242-Cm	99.9	99.9
242-Pu	99.9	99.9
243-Am	99.9	99.9
243-Cm	99.9	99.9
244-Cm	99.9	99.9
3-H	0	0
59-Ni	28.57142857	28.57142857
60-Co	99.9	99.9
63-Ni	28.57142857	28.57142857
79-Se	97.2299169	97.2299169
90-Sr	44.444	44.444
90-Y	44.444	44.444
93-Zr	44.44444444	44.44444444
93m-Nb	99.9	99.9
99-Tc	99.9	99.9
Ag+	99.9	99.9
Al(OH)3	65.51724138	65.51724138
Al(OH)4-	65.51724138	65.51724138
Al+3	65.51724138	65.51724138
As+5	96.06299213	96.06299213
B+3	92	92
Ba+2	99.9	99.9
Be+2	99.9	99.9
Bi+3	99.9	99.9

HOP-WESP-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	0	0
C12H27O4P	0	0
C12H4Cl6	99.58333333	99.58333333
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	99.58333333	99.58333333
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	99.58333333	99.58333333
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	73.68421053	73.68421053
CCl4	0	0
Cd+2	79.16666667	79.16666667
Ce+3	99.9	99.9
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	89.47368421	89.47368421
CN-	97.2826087	97.2826087
Co+3	88.50574713	88.50574713
CO3-2	97.2826087	97.2826087
Cr(OH)4-	88.0952381	88.0952381
Cr(TOTAL)	88.0952381	88.0952381
Cs+	94.56521739	94.56521739
Cu+2	33.33333333	33.33333333
F-	50	50
Fe+3	88.37209302	88.37209302
H+	99.9	99.9
H2CO3	99.58333333	99.58333333

HOP-WESP-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
H2O	0	0
H2O2	0	0
HCO3-	97.2826087	97.2826087
Hg+2	0	0
K+	82.45614035	82.45614035
La+3	99.9	99.9
Li+	95	95
H2O(BOUND)	0	0
LS10	0	0
PPG	0	0
DPPG	0	0
PDMS	0	0
DPDMS	0	0
NO3-D	0	0
AlOOH	0	0
LS9	0	0
Mg+2	28.57142857	28.57142857
Mn+4	37.5	37.5
MnO2	37.5	37.5
MnO4-	37.5	37.5
Mnp	37.5	37.5
Mo+6	99.9	99.9
Na+	97.2826087	97.2826087
Nap+	97.2826087	97.2826087
Nd+3	99.9	99.9
NH3	9.90990991	9.90990991
NH4+	9.90990991	9.90990991
Ni+2	28.57142857	28.57142857
NO2-	97.2826087	97.2826087
NO3-	97.2826087	97.2826087
O-2	0	0
OH(BOUND)	99.9	99.9
OH-	99.9	99.9
Pb+2	81.81818182	81.81818182
Pd+2	99.9	99.9
PO4-3	61.53846154	61.53846154
PO4-3(HARD)	0	0
Pr+3	99.9	99.9
Pu+4	99.9	99.9
Rb+	99.9	99.9
Rh+3	99.9	99.9
Ru+3	95.4954955	95.4954955
Sb+5	82.45614035	82.45614035
Se+6	97.2299169	97.2299169
Si+4	89.47368421	89.47368421
SO4-2	98.32214765	98.32214765
Sr+2	44.44444444	44.44444444

HOP-WESP-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
Ta+5	99.9	99.9
Tc+7	99.9	99.9
Te+6	99.28469242	99.28469242
Th+4	99.9	99.9
Ti+4	33.33333333	33.33333333
Tl+3	99.9	99.9
TOC	0	0
U(TOTAL)	99.9	99.9
V+5	99.9	99.9
W+6	99.9	99.9
Y+3	99.9	99.9
Zn+2	86.66666667	86.66666667
Zr+4	44.44444444	44.44444444

Table D-22 HLW HEME Splits

HOP-HEME-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
106-Ru	99.6969697	99.6969697
113m-Cd	99.6875	99.6875
125-Sb	99.62962963	99.62962963
126-Sn	99.67741935	99.67741935
129-I	0	0
134-Cs	99.6875	99.6875
137-Cs	99.688	99.688
137m-Ba	99.688	99.688
14-C	0	0
151-Sm	99.67741935	99.67741935
152-Eu	99.67741935	99.67741935
154-Eu	99.67741935	99.67741935
155-Eu	99.67741935	99.67741935
226-Ra	99.67741935	99.67741935
227-Ac	99.67741935	99.67741935
228-Ra	99.67741935	99.67741935
229-Th	99.67741935	99.67741935
231-Pa	99.67741935	99.67741935
232-Th	99.67741935	99.67741935
232-U	99.67741935	99.67741935
233-U	99.67741935	99.67741935
234-U	99.67741935	99.67741935
235-U	99.67741935	99.67741935
236-U	99.67741935	99.67741935
237-Np	99.67741935	99.67741935
238-Pu	99.67741935	99.67741935
238-U	99.67741935	99.67741935
239-Pu	99.67741935	99.67741935
240-Pu	99.67741935	99.67741935
241-Am	99.67741935	99.67741935

HOP-HEME-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
241-Pu	99.67741935	99.67741935
242-Cm	99.67741935	99.67741935
242-Pu	99.67741935	99.67741935
243-Am	99.67741935	99.67741935
243-Cm	99.67741935	99.67741935
244-Cm	99.67741935	99.67741935
3-H	0	0
59-Ni	99.66666667	99.66666667
60-Co	99.6969697	99.6969697
63-Ni	99.66666667	99.66666667
79-Se	99.6875	99.6875
90-Sr	99.667	99.667
90-Y	99.667	99.667
93-Zr	99.65517241	99.65517241
93m-Nb	99.67741935	99.67741935
99-Tc	99.67741935	99.67741935
Ag+	99.67741935	99.67741935
Al(OH)3	99.67741935	99.67741935
Al(OH)4-	99.67741935	99.67741935
Al+3	99.67741935	99.67741935
As+5	99.6969697	99.6969697
B+3	99.677	99.677
Ba+2	99.67741935	99.67741935
Be+2	99.67741935	99.67741935
Bi+3	99.67741935	99.67741935
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	0	0
C12H27O4P	0	0
C12H4Cl6	99.79591837	99.79591837
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	99.79591837	99.79591837
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	99.79591837	99.79591837
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0

HOP-HEME-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	99.66666667	99.66666667
CCl4	0	0
Cd+2	99.6875	99.6875
Ce+3	99.66666667	99.66666667
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	99.6875	99.6875
CN-	99.6875	99.6875
Co+3	99.6969697	99.6969697
CO3-2	99.6875	99.6875
Cr(OH)4-	99.70588235	99.70588235
Cr(TOTAL)	99.70588235	99.70588235
Cs+	99.6875	99.6875
Cu+2	99.67741935	99.67741935
DPDMS	0	0
DPPG	0	0
F-	99.6969697	99.6969697
Fe+3	99.67741935	99.67741935
H+	99.9	99.9
H2CO3	99.6875	99.6875
H2O	0	0
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	99.6875	99.6875
Hg+2	0	0
K+	99.6875	99.6875
La+3	99.66666667	99.66666667
Li+	99.6875	99.6875
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	99.66666667	99.66666667
Mn+4	99.66666667	99.66666667
MnO2	99.66666667	99.66666667
MnO4-	99.66666667	99.66666667
Mnp	99.66666667	99.66666667
Mo+6	99.6969697	99.6969697
Na+	99.6875	99.6875
Nap+	99.6875	99.6875
Nd+3	99.66666667	99.66666667

HOP-HEME-00001/2	Liquid %	Solid %
Components	to HOP-SCB-00001/2	to HOP-SCB-00001/2
NH3	9.90990991	9.90990991
NH4+	9.90990991	9.90990991
Ni+2	99.66666667	99.66666667
NO2-	99.6875	99.6875
NO3-	99.6875	99.6875
NO3-D	0	0
O-2	0	0
OH(BOUND)	99.6875	99.6875
OH-	99.6875	99.6875
Pb+2	99.6875	99.6875
Pd+2	99.67741935	99.67741935
PDMS	0	0
PO4-3	99.6875	99.6875
PO4-3(HARD)	0	0
PPG	0	0
Pr+3	99.67741935	99.67741935
Pu+4	99.67741935	99.67741935
Rb+	99.67741935	99.67741935
Rh+3	99.67741935	99.67741935
Ru+3	99.6969697	99.6969697
Sb+5	99.62962963	99.62962963
Se+6	99.6875	99.6875
Si+4	99.67741935	99.67741935
SO4-2	99.6875	99.6875
Sr+2	99.66666667	99.66666667
Ta+5	99.67741935	99.67741935
Tc+7	99.67741935	99.67741935
Te+6	99.6875	99.6875
Th+4	99.67741935	99.67741935
Ti+4	99.65517241	99.65517241
Tl+3	99.67741935	99.67741935
TOC	0	0
U(TOTAL)	99.67741935	99.67741935
V+5	99.70588235	99.70588235
W+6	99.67741935	99.67741935
Y+3	99.67741935	99.67741935
Zn+2	99.67741935	99.67741935
Zr+4	99.65517241	99.65517241

Table D-23 HLW HEPA Splits**HOP-HEPA-00001-2AB****HOP-HEPA-00007-8AB****Components****Liquid %
to Accumulate****Solid %
to Accumulate**

106-Ru	99.99994	99.99994
113m-Cd	99.99994	99.99994
125-Sb	99.99994	99.99994
126-Sn	99.99994	99.99994
129-I	0	0
134-Cs	99.99994	99.99994
137-Cs	99.99994	99.99994
137m-Ba	99.99994	99.99994
14-C	0	0
151-Sm	99.99994	99.99994
152-Eu	99.99994	99.99994
154-Eu	99.99994	99.99994
155-Eu	99.99994	99.99994
226-Ra	99.99994	99.99994
227-Ac	99.99994	99.99994
228-Ra	99.99994	99.99994
229-Th	99.99994	99.99994
231-Pa	99.99994	99.99994
232-Th	99.99994	99.99994
232-U	99.99994	99.99994
233-U	99.99994	99.99994
234-U	99.99994	99.99994
235-U	99.99994	99.99994
236-U	99.99994	99.99994
237-Np	99.99994	99.99994
238-Pu	99.99994	99.99994
238-U	99.99994	99.99994
239-Pu	99.99994	99.99994
240-Pu	99.99994	99.99994
241-Am	99.99994	99.99994
241-Pu	99.99994	99.99994
242-Cm	99.99994	99.99994
242-Pu	99.99994	99.99994
243-Am	99.99994	99.99994
243-Cm	99.99994	99.99994
244-Cm	99.99994	99.99994
3-H	0	0
59-Ni	99.99994	99.99994
60-Co	99.99994	99.99994
63-Ni	99.99994	99.99994
79-Se	99.99994	99.99994
90-Sr	99.99994	99.99994
90-Y	99.99994	99.99994
93-Zr	99.99994	99.99994
93m-Nb	99.99994	99.99994
99-Tc	99.99994	99.99994

HOP-HEPA-00001-2AB

HOP-HEPA-00007-8AB

Components

	Liquid % to Accumulate	Solid % to Accumulate
Ag+	99.99994	99.99994
Al(OH)3	99.99994	99.99994
Al(OH)4-	99.99994	99.99994
Al+3	99.99994	99.99994
As+5	99.99994	99.99994
B+3	99.97	99.97
Ba+2	99.99994	99.99994
Be+2	99.99994	99.99994
Bi+3	99.99994	99.99994
C10H12N2O8-4	99.99994	99.99994
C10H15N2O7-3	99.99994	99.99994
C10H8	99.99994	99.99994
C12H27O4P	99.99994	99.99994
C12H4Cl6	99.99994	99.99994
C12H8	99.99994	99.99994
C13H28	99.99994	99.99994
C2Cl4	99.99994	99.99994
C2H3N	99.99994	99.99994
C2H3O2-	99.99994	99.99994
C2H3O3-	99.99994	99.99994
C2H6SiO	99.99994	99.99994
C2H8N2	99.99994	99.99994
C2HCl3	99.99994	99.99994
C2O4-2	99.99994	99.99994
C3H6O	99.99994	99.99994
C4H10O	99.99994	99.99994
C4H7NO4	99.99994	99.99994
C4H8O	99.99994	99.99994
C5H5N	99.99994	99.99994
C6H5NO2	99.99994	99.99994
C6H5O7-3	99.99994	99.99994
C6H6	99.99994	99.99994
C6H6O	99.99994	99.99994
C7H6N2O4	99.99994	99.99994
C7H8	99.99994	99.99994
C7H8O	99.99994	99.99994
C8H8O	99.99994	99.99994
Ca+2	99.99994	99.99994
CCl4	99.99994	99.99994
Cd+2	99.99994	99.99994
Ce+3	99.99994	99.99994
CH2Cl2	99.99994	99.99994
CHCl3	99.99994	99.99994
CHO2-	99.99994	99.99994
Cl-	99.99994	99.99994
CN-	99.99994	99.99994
Co+3	99.99994	99.99994

HOP-HEPA-00001-2AB

HOP-HEPA-00007-8AB

Components

	Liquid % to Accumulate	Solid % to Accumulate
CO3-2	99.99994	99.99994
Cr(OH)4-	99.99994	99.99994
Cr(TOTAL)	99.99994	99.99994
Cs+	99.99994	99.99994
Cu+2	99.99994	99.99994
DPDMS	99.99994	99.99994
DPPG	99.99994	99.99994
F-	99.99994	99.99994
Fe+3	99.99994	99.99994
H+	99.99994	99.99994
H2CO3	99.99994	99.99994
H2O	0	0
H2O(BOUND)	99.99994	99.99994
H2O2	99.99994	99.99994
HCO3-	99.99994	99.99994
Hg+2	0	0
K+	99.99994	99.99994
La+3	99.99994	99.99994
Li+	99.99994	99.99994
LS10	99.99994	99.99994
AlOOH	99.99994	99.99994
LS9	99.99994	99.99994
Mg+2	99.99994	99.99994
Mn+4	99.99994	99.99994
MnO2	99.99994	99.99994
MnO4-	99.99994	99.99994
Mnp	99.99994	99.99994
Mo+6	99.99994	99.99994
Na+	99.99994	99.99994
Nap+	99.99994	99.99994
Nd+3	99.99994	99.99994
NH3	99.99994	99.99994
NH4+	99.99994	99.99994
Ni+2	99.99994	99.99994
NO2-	0	0
NO3-	99.99994	99.99994
NO3-D	99.99994	99.99994
O-2	99.99994	99.99994
OH(BOUND)	99.99994	99.99994
OH-	99.99994	99.99994
Pb+2	99.99994	99.99994
Pd+2	99.99994	99.99994
PDMS	99.99994	99.99994
PO4-3	99.99994	99.99994
PO4-3(HARD)	99.99994	99.99994
PPG	99.99994	99.99994
Pr+3	99.99994	99.99994

HOP-HEPA-00001-2AB

HOP-HEPA-00007-8AB

Components

	Liquid % to Accumulate	Solid % to Accumulate
Pu+4	99.99994	99.99994
Rb+	99.99994	99.99994
Rh+3	99.99994	99.99994
Ru+3	99.99994	99.99994
Sb+5	99.99994	99.99994
Se+6	99.99994	99.99994
Si+4	99.99994	99.99994
SO4-2	99.99994	99.99994
Sr+2	99.99994	99.99994
Ta+5	99.99994	99.99994
Tc+7	99.99994	99.99994
Te+6	99.99994	99.99994
Th+4	99.99994	99.99994
Ti+4	99.99994	99.99994
Tl+3	99.99994	99.99994
TOC	99.99994	99.99994
U(TOTAL)	99.99994	99.99994
V+5	99.99994	99.99994
W+6	99.99994	99.99994
Y+3	99.99994	99.99994
Zn+2	99.99994	99.99994
Zr+4	99.99994	99.99994

Gas Components

	Gas % to ACCUMULATE
129-I	0
C12H4Cl6	99.99994
C2H3N	99.99994
CO2	0
H2O	0
HCl	0
HF	0
Hg	99.99994
N2	0
NH3	99.99994
NO	0
NO2	0
O2	0
P2O5	99.99994
SO2	0
SO3	99.99994

Table D-24 HLW Carbon Absorber Splits**HOP-ADBR-00001AB****HOP-ADBR-00002AB****Components****Liquid %
to Accumulate****Solid %
to Accumulate**

106-Ru	0	0
113m-Cd	0	0
125-Sb	0	0
126-Sn	0	0
129-I	0	0
134-Cs	0	0
137-Cs	0	0
137m-Ba	0	0
14-C	0	0
151-Sm	0	0
152-Eu	0	0
154-Eu	0	0
155-Eu	0	0
226-Ra	0	0
227-Ac	0	0
228-Ra	0	0
229-Th	0	0
231-Pa	0	0
232-Th	0	0
232-U	0	0
233-U	0	0
234-U	0	0
235-U	0	0
236-U	0	0
237-Np	0	0
238-Pu	0	0
238-U	0	0
239-Pu	0	0
240-Pu	0	0
241-Am	0	0
241-Pu	0	0
242-Cm	0	0
242-Pu	0	0
243-Am	0	0
243-Cm	0	0
244-Cm	0	0
3-H	0	0
59-Ni	0	0
60-Co	0	0
63-Ni	0	0
79-Se	0	0
90-Sr	0	0
90-Y	0	0
93-Zr	0	0
93m-Nb	0	0

HOP-ADBR-00001AB**HOP-ADBR-00002AB****Components**

	Liquid % to Accumulate	Solid % to Accumulate
99-Tc	0	0
Ag+	0	0
Al(OH) ₃	0	0
Al(OH) ₄ ⁻	0	0
Al ⁺³	0	0
As ⁺⁵	0	0
B ⁺³	0	0
Ba ⁺²	0	0
Be ⁺²	0	0
Bi ⁺³	0	0
C ₁₀ H ₁₂ N ₂ O ₈ -4	0	0
C ₁₀ H ₁₅ N ₂ O ₇ -3	0	0
C ₁₀ H ₈	0	0
C ₁₂ H ₂₇ O ₄ P	0	0
C ₁₂ H ₄ Cl ₆	90	90
C ₁₂ H ₈	0	0
C ₁₃ H ₂₈	0	0
C ₂ Cl ₄	0	0
C ₂ H ₃ N	0	0
C ₂ H ₃ O ₂ ⁻	0	0
C ₂ H ₃ O ₃ ⁻	0	0
C ₂ H ₆ SiO	0	0
C ₂ H ₈ N ₂	0	0
C ₂ HCl ₃	0	0
C ₂ O ₄ ⁻²	0	0
C ₃ H ₆ O	0	0
C ₄ H ₁₀ O	0	0
C ₄ H ₇ NO ₄	0	0
C ₄ H ₈ O	0	0
C ₅ H ₅ N	0	0
C ₆ H ₅ NO ₂	0	0
C ₆ H ₅ O ₇ -3	0	0
C ₆ H ₆	0	0
C ₆ H ₆ O	0	0
C ₇ H ₆ N ₂ O ₄	0	0
C ₇ H ₈	0	0
C ₇ H ₈ O	0	0
C ₈ H ₈ O	0	0
Ca ⁺²	0	0
CCl ₄	0	0
Cd ⁺²	0	0
Ce ⁺³	0	0
CH ₂ Cl ₂	0	0
CHCl ₃	0	0
CHO ₂ ⁻	0	0
Cl ⁻	0	0
CN ⁻	0	0

HOP-ADBR-00001AB

HOP-ADBR-00002AB

Components

**Liquid %
to Accumulate**

**Solid %
to Accumulate**

Co+3	0	0
CO3-2	0	0
Cr(OH)4-	0	0
Cr(TOTAL)	0	0
Cs+	0	0
Cu+2	0	0
DPDMS	0	0
DPPG	0	0
F-	0	0
Fe+3	0	0
H+	0	0
H2CO3	0	0
H2O	0	0
H2O(BOUND)	0	0
H2O2	0	0
HCO3-	0	0
Hg+2	0	0
K+	0	0
La+3	0	0
Li+	0	0
LS10	0	0
AlOOH	0	0
LS9	0	0
Mg+2	0	0
Mn+4	0	0
MnO2	0	0
MnO4-	0	0
Mnp	0	0
Mo+6	0	0
Na+	0	0
Nap+	0	0
Nd+3	0	0
NH3	0	0
NH4+	0	0
Ni+2	0	0
NO2-	0	0
NO3-	0	0
NO3-D	0	0
O-2	0	0
OH(BOUND)	0	0
OH-	0	0
Pb+2	0	0
Pd+2	0	0
PDMS	0	0
PO4-3	0	0
PO4-3(HARD)	0	0
PPG	0	0

HOP-ADBR-00001AB

HOP-ADBR-00002AB

Components

	Liquid % to Accumulate	Solid % to Accumulate
Pr+3	0	0
Pu+4	0	0
Rb+	0	0
Rh+3	0	0
Ru+3	0	0
Sb+5	0	0
Se+6	0	0
Si+4	0	0
SO4-2	0	0
Sr+2	0	0
Ta+5	0	0
Tc+7	0	0
Te+6	0	0
Th+4	0	0
Ti+4	0	0
Tl+3	0	0
TOC	0	0
U(TOTAL)	0	0
V+5	0	0
W+6	0	0
Y+3	0	0
Zn+2	0	0
Zr+4	0	0

Gas Components

	Gas % to ACCUMULATE
129-I	0
C12H4Cl6	90
C2H3N	0
CO2	0
H2O	0
HCl	0
HF	0
Hg	99.9
N2	0
NH3	0
NO	0
NO2	0
O2	0
P2O5	0
SO2	0
SO3	0

Table D-25 HLW Silver Mordenite Splits

HOP-ABS-00002/3 Components	Liquid % to Accumulate	Solid % to Accumulate
106-Ru	0	0
113m-Cd	0	0
125-Sb	0	0
126-Sn	0	0
129-I	0	0
134-Cs	0	0
137-Cs	0	0
137m-Ba	0	0
14-C	0	0
151-Sm	0	0
152-Eu	0	0
154-Eu	0	0
155-Eu	0	0
226-Ra	0	0
227-Ac	0	0
228-Ra	0	0
229-Th	0	0
231-Pa	0	0
232-Th	0	0
232-U	0	0
233-U	0	0
234-U	0	0
235-U	0	0
236-U	0	0
237-Np	0	0
238-Pu	0	0
238-U	0	0
239-Pu	0	0
240-Pu	0	0
241-Am	0	0
241-Pu	0	0
242-Cm	0	0
242-Pu	0	0
243-Am	0	0
243-Cm	0	0
244-Cm	0	0
3-H	0	0
59-Ni	0	0
60-Co	0	0
63-Ni	0	0
79-Se	0	0
90-Sr	0	0
90-Y	0	0
93-Zr	0	0
93m-Nb	0	0
99-Tc	0	0

HOP-ABS-00002/3**Components****Liquid %
to Accumulate****Solid %
to Accumulate**

Ag+	0	0
Al(OH)3	0	0
Al(OH)4-	0	0
Al+3	0	0
As+5	0	0
B+3	0	0
Ba+2	0	0
Be+2	0	0
Bi+3	0	0
C10H12N2O8-4	0	0
C10H15N2O7-3	0	0
C10H8	0	0
C12H27O4P	0	0
C12H4Cl6	0	0
C12H8	0	0
C13H28	0	0
C2Cl4	0	0
C2H3N	0	0
C2H3O2-	0	0
C2H3O3-	0	0
C2H6SiO	0	0
C2H8N2	0	0
C2HCl3	0	0
C2O4-2	0	0
C3H6O	0	0
C4H10O	0	0
C4H7NO4	0	0
C4H8O	0	0
C5H5N	0	0
C6H5NO2	0	0
C6H5O7-3	0	0
C6H6	0	0
C6H6O	0	0
C7H6N2O4	0	0
C7H8	0	0
C7H8O	0	0
C8H8O	0	0
Ca+2	0	0
CCl4	0	0
Cd+2	0	0
Ce+3	0	0
CH2Cl2	0	0
CHCl3	0	0
CHO2-	0	0
Cl-	0	0
CN-	0	0
Co+3	0	0

HOP-ABS-00002/3**Components****Liquid %
to Accumulate****Solid %
to Accumulate**

CO3-2	0	0
Cr(OH)4-	0	0
Cr(TOTAL)	0	0
Cs+	0	0
Cu+2	0	0
F-	0	0
Fe+3	0	0
H+	0	0
H2CO3	0	0
H2O	0	0
H2O2	0	0
HCO3-	0	0
Hg+2	0	0
K+	0	0
La+3	0	0
Li+	0	0
H2O(BOUND)	0	0
LS10	0	0
PO4-3(HARD)	0	0
PPG	0	0
DPPG	0	0
PDMS	0	0
DPDMS	0	0
NO3-D	0	0
AlOOH	0	0
LS9	0	0
Mg+2	0	0
Mn+4	0	0
MnO2	0	0
MnO4-	0	0
Mnp	0	0
Mo+6	0	0
Na+	0	0
Nap+	0	0
Nd+3	0	0
NH3	0	0
NH4+	0	0
Ni+2	0	0
NO2-	0	0
NO3-	0	0
O-2	0	0
OH(BOUND)	0	0
OH-	0	0
Pb+2	0	0
Pd+2	0	0
PO4-3	0	0
Pr+3	0	0

HOP-ABS-00002/3	Liquid %	Solid %
Components	to Accumulate	to Accumulate
Pu+4	0	0
Rb+	0	0
Rh+3	0	0
Ru+3	0	0
Sb+5	0	0
Se+6	0	0
Si+4	0	0
SO4-2	0	0
Sr+2	0	0
Ta+5	0	0
Tc+7	0	0
Te+6	0	0
Th+4	0	0
Ti+4	0	0
Tl+3	0	0
TOC	0	0
U(TOTAL)	0	0
V+5	0	0
W+6	0	0
Y+3	0	0
Zn+2	0	0
Zr+4	0	0
Gas Components	Gas %	
	to ACCUMULATE	
129-I	99.9	
C12H4Cl6	0	
C2H3N	0	
CO2	0	
Hg	0	
H2O	0	
HCl	99.9	
HF	99.9	
N2	0	
NH3	0	
NO	0	
NO2	0	
O2	0	
P2O5	0	
SO2	0	
SO3	0	

Table D-26 HLW NOx Scrubber Splits

HOP-SCR-00001/2	Liquid %	Solid %
Components	to Accumulate	to Accumulate
C2O4-2	0	0
Gas Components	Gas %	
	to Accumulate	

CO2	0
H2O	0
HCl	0
HF	0
N2	0
NH3	0
NO	0
NO2	0
O2	0
P2O5	0
SO2	0

Table D-27 HLW PJV HEPA Splits

PJV-HEPA-00004-5	Liquid %	Solid %
Components	to Accumulate	to Accumulate
106-Ru	0	0
	Gas %	
Gas Components	to Accumulate	
CO2	0	

Appendix E

Vessel Parameter Table

Appendix E
Vessel Parameter Table

Vessel parameters such as maximum volumes, set volumes, minimum volumes, maximum flowrates, and sample hold times are the most fundamental operating parameters in the development of the dynamic flowsheet. These parameters set the physical limits on how vessels are filled, emptied, sampled, and pumped. Maximum operating temperatures are assigned to some equipment of interests where hydrogen generation rates are calculated.

Table E-1 Vessel Parameters

Equipment Tag No.	Equipment name	Overflow Volume (gal)	Maximum Volume (gal)	Set Volume (gal)	Minimum Volume (gal)	Maximum Flowrate (gpm)	Sample Hold Time (hours)	Maximum Temperature (°F)	Descriptions
CNP-EVAP-00001	Cesium Evaporator Separator Vessel	n/a	2,130	2,128	130	20	n/a	140	Add 2,128 gallons of 5M nitric acid initially and after each discharge
CNP-VSL-00003	Eluate Contingency Storage Vessel	18,750	16,127	13,127	3,627	62	0.00	190	Per design values
CNP-VSL-00004	Recovered Nitric Acid Vessel	10,064	7,342	5,342	1,342	20	0.00	n/a	Flow rate = 10 gpm for IX elution, 20 gpm for resin outlet flush
CRP-VSL-00001	Cesium Resin Addition Vessel	2,500	2,146	n/a	0	60	0.00	n/a	Set volume is not used
CXP-VSL-00001	Cesium IX Feed Vessel	92,843	84,431	n/a	5,931	30	0.00	n/a	Eliminated from design
CXP-VSL-00004	Cesium IX Caustic Rinse Collection Vessel	n/a	n/a	n/a	n/a	n/a	0.00	n/a	Combined with UFP-VSL-00062A/B/C into a Supertank (see UFP-VSL-00062A for details)
CXP-VSL-00005	Reagent	1,003	454	404	304	30	n/a	n/a	Supply diluted caustic for IXC displacement operation
CXP-VSL-00026A	Treated LAW Collection Vessel	33,335	29,768	28,768	2,268	34	7.5	n/a	Flow rate = 34 gpm for single input, 30 gpm for dual pumping
CXP-VSL-00026B	Treated LAW Collection Vessel	33,335	29,768	28,768	2,268	34	7.5	n/a	Flow rate = 34 gpm for single input, 30 gpm for dual pumping
CXP-VSL-00026C	Treated LAW Collection Vessel	33,335	29,768	28,768	2,268	34	7.5	n/a	Flow rate = 34 gpm for single input, 30 gpm for dual pumping
FEP-DMST-00001A	Waste Feed Evaporator Demister	n/a	1,300	850	50	80	0.00	n/a	Per design values
FEP-DMST-00001B	Waste Feed Evaporator Demister	n/a	1,300	850	50	80	0.00	n/a	Reserved capability
FEP-SEP-00001A	Waste Feed Evaporator	n/a	4,819	2,820	0	28/45	n/a	n/a	Boiloff rate = maximum boiloff (30) - reflux (2) Concentrate flow rate = 45 gpm
FEP-SEP-00001B	Waste Feed Evaporator	n/a	4,819	2,820	0	28/45	n/a	n/a	Reserved capability
FEP-VSL-00005A	Waste Feed Evaporator Condensate Vessel	4,144	1,280	1,080	310	60	0.00	n/a	Per design values
FEP-VSL-00005B	Waste Feed Evaporator Condensate Vessel	4,144	1,280	1,080	310	60	0.00	n/a	Reserved capability
FEP-VSL-00017A	Waste Feed Evaporator Feed Vessel	69,292	55,692	50,692	5,692	50	0.00	122	Actual flow rate varies to satisfy boiloff rate, evaporator concentrate SpG and wt% solids requirements
FEP-VSL-00017B	Waste Feed Evaporator Feed Vessel	69,292	55,692	50,692	5,692	50	0.00	122	Actual flow rate varies to satisfy boiloff rate, evaporator concentrate SpG and wt% solids requirements
FRP-VSL-00002A	Waste Feed Receipt Vessel	403,592	379,391	309,391	4,391	125	14.20	120	Per design values
FRP-VSL-00002B	Waste Feed Receipt Vessel	403,592	379,391	369,391	4,391	125	14.20	120	Per design values
FRP-VSL-00002C	Waste Feed Receipt Vessel	403,592	379,391	369,391	4,391	125	14.20	120	Per design values
FRP-VSL-00002D	Waste Feed Receipt Vessel	403,592	379,391	369,391	4,391	125	14.20	120	Per design values
GFR-TK-00022	LAW Glass Former Feed Hopper	n/a	3,516		3,516	49	0.0	n/a	Per design values
GFR-TK-00023	LAW Glass Former Feed Hopper	n/a	3,516		3,516	49	0.0	n/a	Per design values

Equipment Tag No.	Equipment name	Overflow Volume (gal)	Maximum Volume (gal)	Set Volume (gal)	Minimum Volume (gal)	Maximum Flowrate (gpm)	Sample Hold Time (hours)	Maximum Temperature (°F)	Descriptions
GFR-TK-00025	HLW Glass Former Feed Hopper	n/a	2,394		2,394	33.3	0.0	n/a	Per design values
GFR-TK-00031	HLW Glass Former Feed Hopper	n/a	2,394		2,394	33.3	0.0	n/a	Per design values
HDH-VSL-00001	Canister Rinse Bogie Decon Vessel	360	360	360	0	80	0.00	n/a	Per design values
HDH-VSL-00002	Canister Decontamination Vessel	210	215	215	0	48	0.00	n/a	Decon vessel discharge logic is modified to work with the updated volume.
HDH-VSL-00003	Waste Neutralization Vessel	4,142	3,647	3,647	675	58	0.00	n/a	Per design values
HDH-VSL-00004	Canister Decontamination Vessel	213	215	215	0	48	0.00	n/a	Decon vessel discharge logic is modified to work with the updated volume.
HFP-VSL-00001	HLW Melter Feed Preparation Vessel	7,650	5,661	Variable	1,356	44	12.79, 9.59	140	Set volume is dynamically calculated
HFP-VSL-00002	HLW Melter Feed Vessel	7,646	7,208	1,563	1,543	Variable	0.00	140	Lower set volume triggers pumping from MFPV while continue emptying, flow rate is dynamically calculated to meet IHLW glass production rate
HFP-VSL-00005	HLW Melter Feed Preparation Vessel	7,650	5,661	Variable	1,356	44	12.79, 9.59	140	Set volume is dynamically calculated
HFP-VSL-00006	HLW Melter Feed Vessel	7,646	7,208	1,563	1,543	Variable	0.00	140	Lower set volume triggers pumping from MFPV while continue emptying, flow rate is dynamically calculated to meet IHLW glass production rate
HLP-VSL-00022	HLW Feed Receipt Vessel	231,161	174,486	170,000	29,486	155	16.4	150	Per design values
HLP-VSL-00027A	HLW Lag Storage Vessel	111,376	92,600	61,800	10,600	90	0.00	138	Per design values
HLP-VSL-00027B	HLW Lag Storage Vessel	111,376	92,600	61,800	10,600	90	0.00	138	Secondary choice for receiving CNP evaporator concentrate
HLP-VSL-00028	HLW Feed Blend Vessel	122,233	103,000	100,000	27,000	56	12.45	141	Primary choice for receiving CNP evaporator concentrate
IHLW1	IHLW Canister	n/a	300	n/a	0	n/a	n/a	n/a	Used to track HLW canister count and composition
IHLW2	IHLW Canister	n/a	300	n/a	0	n/a	n/a	n/a	Used to track HLW canister count and composition
HMP-MLTR-00001	HLW Melter 1	1,217	1,092	1,067	1,067	250	n/a	n/a	Flow rate is set high enough to ensure instant glass pouring
HMP-MLTR-00002	HLW Melter 2	1,217	1,092	1,067	1,067	250	n/a	n/a	Flow rate is set high enough to ensure instant glass pouring
HOP-SCB-00001 (combined)	HLW Submerged Bed Scrubber	11,227	9,137	8,137	1,758	80	n/a	140	Column is modeled to also assume the function of HOP-VSL-00903. Maximum accumulation time = 24 hours
HOP-SCB-00002 (combined)	HLW Submerged Bed Scrubber	11,227	9,137	8,137	1,758	80	n/a	140	Column is modeled to also assume the function of HOP-VSL-00904. Maximum accumulation time = 24 hours
HOP-VSL-00903	HLW SBS Condensate Receiver Vessel	7,898	5,808	n/a	1,758	80	n/a	n/a	Combined with HOP-SCB-00001
HOP-VSL-00904	HLW SBS Condensate Receiver Vessel	7,898	5,808	n/a	1,758	80	n/a	n/a	Combined with HOP-SCB-00002
ILAW1	ILAW Container	n/a	564	n/a	0	n/a	n/a	n/a	Used to track LAW container count and composition
ILAW2	ILAW Container	n/a	564	n/a	0	n/a	n/a	n/a	Used to track LAW container count and composition
LCP-VSL-00001	LAW Concentrate Receipt Vessel	14,877	12,855	12,855	3,740	88	14.5	n/a	Set volume is lower set point and is dynamically calculated to ensure that partial batch transfer to MFPV will not occur
LCP-VSL-00002	LAW Concentrate Receipt Vessel	14,877	12,855	12,855	3,740	88	14.5	n/a	Set volume is lower set point and is dynamically calculated to ensure that partial batch transfer to MFPV will not occur

Equipment Tag No.	Equipment name	Overflow Volume (gal)	Maximum Volume (gal)	Set Volume (gal)	Minimum Volume (gal)	Maximum Flowrate (gpm)	Sample Hold Time (hours)	Maximum Temperature (°F)	Descriptions
LFP-VSL-00001	LAW Melter Feed Preparation Vessel	7,489	5,132	Variable	1,732	50	0.75	140	Set point is dynamically calculated
LFP-VSL-00002	LAW Melter Feed Vessel	5,786	4,377	1,000	977	Variable	0.00	140	Set volume is lower set point, flow rate is dynamically calculated to meet ILAW glass production rate
LFP-VSL-00003	LAW Melter Feed Preparation Vessel	7,489	5,132	Variable	1,732	50	0.75	140	Set point is dynamically calculated
LFP-VSL-00004	LAW Melter Feed Vessel	5,786	4,377	1,000	977	Variable	0.00	140	Set volume is lower set point, flow rate is dynamically calculated to meet ILAW glass production rate
LMP-MLTR-00001	LAW Melter 1	2,318	2,016	1,875	1,875	250	n/a	n/a	Flow rate is set high enough to ensure instant glass pouring
LMP-MLTR-00002	LAW Melter 2	2,318	2,016	1,875	1,875	250	n/a	n/a	Flow rate is set high enough to ensure instant glass pouring
LOP-SCB-00001 (combined volumes)	LAW Submerged Bed Scrubber	10,135	9,980	8,980	451	80	n/a	n/a	Column is modeled to also assume the function of LOP-VSL-00001. Maximum accumulation time = 48 hours
LOP-SCB-00002 (combined volumes)	LAW Submerged Bed Scrubber	10,135	9,980	8,980	451	80	n/a	n/a	Column is modeled to also assume the function of LOP-VSL-00002. Maximum accumulation time = 48 hours
LOP-VSL-00001	LAW SBS Condensate Vessel	6,806	6,651	n/a	451	80	n/a	n/a	Combined with LOP-SCB-00001
LOP-VSL-00002	LAW SBS Condensate Vessel	6,806	6,651	n/a	451	80	n/a	n/a	Combined with LOP-SCB-00002
LVP-TK-00001	Caustic Collection Vessel	7,325	6,032	6,032	2,032	200	0.00	n/a	Per design values
PVP-SCB-00002	Vessel Vent Caustic Scrubber	3,564	1,960	1,960	0	120	n/a	n/a	SBS operates at constant level at 3,300 gallons
PVP-VSL-00001	Vessel Vent HEME Drain Collection Vessel	1,650	1,547	1,047	747	50	0.00	n/a	Per design values
PWD-VSL-00015	Acidic/Alkaline Effluent Vessel	105,864	87,148	82,148	12,148	88	0.00	n/a	10,000 gallon headspace is reserved for pH adjustment
PWD-VSL-00016	Acidic/Alkaline Effluent Vessel	105,864	87,148	82,148	12,148	88	0.00	n/a	10,000 gallon headspace is reserved for pH adjustment
PWD-VSL-00033	Ultimate Overflow Vessel	31,476	20,386	10,386	5,386	88	0.00	141	Dual set points are implemented to allow contingency storage
PWD-VSL-00043	HLW Effluent Transfer Vessel	26,504	20,301	10,301	5,301	88	0.00	141	Dual set points are implemented to allow contingency storage
PWD-VSL-00044	Plant Wash Vessel	88,637	73,644	68,644	13,644	88	0.00	n/a	10,000 gallon headspace is reserved for pH adjustment
RDP-VSL-00002A	Spent Resin Slurry Vessel	12,688	7,525	7,508	8	140	0.00	123	None
RDP-VSL-00002B	Spent Resin Slurry Vessel	12,688	7,525	7,085	8	140	0.25	123	None
RDP-VSL-00002C	Spent Resin Slurry Vessel	12,688	7,525	n/a	8	140	0.00	123	None
RLD-TK-00006A	Process Condensate Vessel	313,500	292,500	200,000	27,500	1,000	0.00	n/a	Per design values
RLD-TK-00006B	Process Condensate Vessel	313,500	292,500	200,000	27,500	170	0.00	n/a	Per design values
RLD-VSL-00003	Plant Wash Vessel	22,650	19,164	n/a	3,164	130	0.00	n/a	Contingency vessel, not used in model
RLD-VSL-00004	C3/C5 Drains/Sump Collection Vessel	6,291	5,887	5,387	1,387	75	0.00	n/a	Per design values
RLD-VSL-00005	SBS Condensate Collection Vessel	23,400	20,300	17,300	4,300	130	0.00	166	Per design values
RLD-VSL-00007	Acidic Waste Storage Vessel	14,612	11,662	8,662.0	1,794	48	7.8	n/a	Per design values
RLD-VSL-00008	Plant Wash and Drains Vessel	10,624	8,281	n/a	1,416	48	7.8	n/a	Contingency vessel, not used in model
RLD-VSL-00017A	Alkaline Effluent Vessel	23,742	21,870	21,870	1,870	130	10.30	n/a	Per design values
RLD-VSL-00017B	Alkaline Effluent Vessel	23,742	21,870	21,870	1,870	130	10.30	n/a	Per design values
TCP-VSL-00001	Treated LAW Concentrate Storage Vessel	128,845	102,621	75,000	9,621	88	0.00	n/a	Per design values

Equipment Tag No.	Equipment name	Overflow Volume (gal)	Maximum Volume (gal)	Set Volume (gal)	Minimum Volume (gal)	Maximum Flowrate (gpm)	Sample Hold Time (hours)	Maximum Temperature (°F)	Descriptions
TLP-DMST-00001	Treated LAW Evaporator Demister	n/a	1,300	350	50	66	0.00	n/a	Per design values
TLP-SEP-00001	Treated LAW Evaporator	n/a	3,820	2,820	0	28/34	n/a	n/a	Boiloff rate = maximum boiloff (30) - reflux (2) Concentrate flow rate = 34 gpm
TLP-VSL-00002	Treated LAW Evaporator Condensate Vessel	1,705	495	385	131	34	0.00	n/a	Per design values
TLP-VSL-00009A	LAW SBS Condensate Receipt Vessel	114,064	87,450	77,450	7,450	10	0.00	n/a	Discharge at fixed flow rate (max = 40 gpm)
TLP-VSL-00009B	LAW SBS Condensate Receipt Vessel	114,064	87,450	77,450	7,450	10	0.00	n/a	Discharge at fixed flow rate (max = 40 gpm)
UFP-VSL-00001A	Ultrafiltration Feed Preparation Vessel	64,373	52,704	28,300	7,704	140	0.00	194	UFP2 leaching case: set volume = 18,300 gal UFP1 leaching case: set volume = 28,300 gal
UFP-VSL-00001B	Ultrafiltration Feed Preparation Vessel	64,373	52,704	28,300	7,704	140	0.00	194	UFP2 leaching case: set volume = 18,300 gal UFP1 leaching case: set volume = 28,300 gal
UFP-VSL-00002A	Ultrafiltration Feed Vessel	33,767	29,900	16,000 19,000	500	Variable/55/94	12.00	194	UFP2 leaching case: set volume = 16,000 gal UFP1 leaching case: set volume = 19,000 gal Variable flow rate for solid concentration and wash (max = 110 gpm) 55 gpm for Non-Newtonian fluids 94 gpm for Newtonian fluids
UFP-VSL-00002B	Ultrafiltration Feed Vessel	33,767	29,900	26,000/16,000 19,000	500	Variable/55/94	12.00	194	UFP2 leaching case: set volume = 26,000 gal for initial solids concentration (see Section 4.8.3) UFP2 leaching case: set volume = 16,000 gal for after feed split (see Section 4.8.3) UFP1 leaching case: set volume = 19,000 gal Variable flow rate for solid concentration and wash (max = 110 gpm) 55 gpm for Non-Newtonian fluids 94 gpm for Newtonian fluids
UFP-VSL-00062A	Ultrafiltration Permeate Collection Vessel	99,081	78,775	11,800	11,755	70/30	0.00	133	Represents the combined UFP-VSL-00062A/B/C and CXP-VSL-00004. Net discharge flowrate = 30 gpm.
UFP-VSL-00062B	Ultrafiltration Permeate Collection Vessel	n/a	n/a	n/a	n/a	n/a	0.00	n/a	Combined with UFP-VSL-00062A/B/C into a Supertank (see UFP-VSL-00062A for details)
UFP-VSL-00062C	Ultrafiltration Permeate Collection Vessel	n/a	n/a	n/a	n/a	n/a	0.00	n/a	Combined with UFP-VSL-00062A/B/C into a Supertank (see UFP-VSL-00062A for details)

Appendix F

Workspace Screenshots

Appendix F

Workspace Screenshots

The WTP process systems are organized graphically in workspaces within which unit operations, chemical reagent sources, and their connections are shown. Also shown on the workspaces are the names of the unit operations and the directions of material flow for the process streams.

Figure F-1 Waste Treatment Plant Overview

Figure F-2 Tank Farm Wastes and Water Sources

Figure F-3 Waste Feed Receipt Process

Figure F-4 Waste Feed Evaporation Process

Figure F-5 Ultrafiltration Process

Figure F-6 Pretreatment Vessel Vent Process and Exhaust System

Figure F-7 Plant Wash and Disposal System

Figure F-8 Cesium Removal Using Ion Exchange Process

Figure F-9 Cesium Fresh Resin Addition and Spent Resin Collection and Dewatering Process

Figure F-10 Cesium Nitric Acid Recovery Process

Figure F-11 Treated LAW Evaporation and Concentrate Storage Process

Figure F-12 LAW Melter Feed Process

Figure F-13 LAW Melter 1 and Associated Primary Offgas Process

Figure F-14 LAW Melter 2 and Associated Primary Offgas Process

Figure F-15 LAW Secondary Offgas/Vessel Vent Process

Figure F-16 LAW Radioactive Liquid Waste Disposal

Figure F-17 HLW Lag Storage and Feed Blending Process

Figure F-18 HLW Melter Feed Process

Figure F-19 HLW Melter 1 and Associated Offgas Process

Figure F-20 HLW Melter 2 and Associated Offgas Process

Figure F-21 HLW Canister Decontamination Handling

Figure F-22 HLW Radioactive Liquid Disposal

Figure F-23 Glass Formers Reagent System

Figure F-24 Radioactive Liquid Waste Disposal - Effluent

Figure F-25 Radioactive Liquid Waste Disposal - Pretreatment

Figure F-26 PJM/RFD Air Sources

Appendix G

Dynamic Air Utilization Modeling

Appendix G

Dynamic Air Utilization Modeling

Dynamic air utilization is a legacy modeling capability from Dynamic (G2) Model Version 4.0 that simulates the sparging, PJM and RFD operations, purge flows, bubbler flows, and sump inbleed flows. This modeling capability needs to be verified and validated before it can be used as the WTP process flowsheet has evolved significantly since June 8, 2005. Flowrates for the vessels are shown in Table G-1 where operational logic is also summarized. It is assumed that sparger air is humidified so that it does not evaporate the waste. It is also assumed that none of the air additions will lead to evaporation. Sparger air, purge air, bubbler air, and sump inbleed air will go to the PVP system. PJM suction and discharge air along with the RFD air will go to the PJV system.

Table G-1 PJM/RFD Air Flowrates

Vessel Name	PJM Air Flowrate (acfm)	RFD Air Flowrate (acfm)	Operational Logic
RDP-VSL-00002A	570.0		Run when the vessel is discharging
RDP-VSL-00002B	570.0		Run when the vessel is discharging
RDP-VSL-00002C	570.0		Run when the vessel is discharging
FEP-VSL-00017A	1007.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
FEP-VSL-00017B	1007.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
FRP-VSL-00002A	1660.0		Run from hold time initiation until vessel reaches minimum volume
FRP-VSL-00002B	1660.0		Run from hold time initiation until vessel reaches minimum volume
FRP-VSL-00002C	1660.0		Run from hold time initiation until vessel reaches minimum volume
FRP-VSL-00002D	1660.0		Run from hold time initiation until vessel reaches minimum volume
HLP-VSL-00022	1536.0		Run if volume is above minimum volume
HLP-VSL-00027A	1463.0		Run at 100 % capacity if volume is above minimum volume, run at 33 % capacity if volume is below minimum volume but greater than zero.
HLP-VSL-00027B	1463.0		Run at 100 % capacity if volume is above minimum volume, run at 33 % capacity if volume is below minimum volume but greater than zero.
HLP-VSL-00028	1463.0		Run at 100 % capacity if volume is above minimum volume, run at 33 % capacity if volume is below minimum volume but greater than zero.
UFP-VSL-00001A	884.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
UFP-VSL-00001B	884.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
UFP-VSL-00002A	1294.0		Run at 100 % capacity if volume is above minimum volume, run at 33 % capacity if volume is below minimum volume but greater than zero.

Vessel Name	PJM Air Flowrate (acfm)	RFD Air Flowrate (acfm)	Operational Logic
UFP-VSL-00002B	1294.0		Run at 100 % capacity if volume is above minimum volume, run at 33 % capacity if volume is below minimum volume but greater than zero.
UFP-VSL-00062A	626.0	258.0	PJM runs after vessel is ready to discharge until vessel reaches minimum volume, RFD runs when vessel is discharging
UFP-VSL-00062B	626.0	258.0	PJM runs after vessel is ready to discharge until vessel reaches minimum volume, RFD runs when vessel is discharging
UFP-VSL-00062C	626.0	254.0	PJM runs after vessel is ready to discharge until vessel reaches minimum volume, RFD runs when vessel is discharging
CXP-VSL-00004	133.0	81.0	Both PJM and RFD run when solution is pumped to the IX column for displacement
CNP-VSL-00004	512.0		Run when the vessel is discharging
CNP-VSL-00003	450.0		Run if volume is above minimum volume
PWD-VSL-00044	859.0	175.0	PJM runs from hold time initiation until vessel reaches minimum volume, RFD runs when vessel is discharging
PWD-VSL-00033	1140.0	363.0	PJM runs from hold time initiation until vessel reaches minimum volume, RFD runs when vessel is discharging
PWD-VSL-00043	1140.0	400.0	PJM runs from hold time initiation until vessel reaches minimum volume, RFD runs when vessel is discharging
PWD-VSL-00015	983.0	217.0	PJM runs from hold time initiation until vessel reaches minimum volume, RFD runs when vessel is discharging
PWD-VSL-00016	983.0	186.0	PJM runs from hold time initiation until vessel reaches minimum volume, RFD runs when vessel is discharging
TCP-VSL-00001	983.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
CXP-VSL-00026A	613.0		Run from hold time initiation until vessel reaches minimum volume
CXP-VSL-00026B	613.0		Run from hold time initiation until vessel reaches minimum volume
CXP-VSL-00026C	613.0		Run from hold time initiation until vessel reaches minimum volume
TLP-VSL-00009A	727.0		Run after vessel is ready to discharge and until vessel reaches minimum volume
TLP-VSL-00009B	727.0		Run after vessel is ready to discharge and until vessel reaches minimum volume

Appendix H

Transfer, Sampling, and Time Triggered Line Flushes

Appendix H

Transfer, Sampling, and Time Triggered Line Flushes

Line flushes occur in the Pretreatment, LAW, and HLW facilities. The sources of line flush include process condensate and process water. For the Pretreatment line flush operations, process condensate from RLD-TK-00006A is the preferred source if sufficient volume is available at the time when it is needed. Process water is the secondary source and will only be used if the primary source is unavailable or insufficient. For the LAW and HLW line flush operations, process water is the only source. Logic triggering the flushes are discussed in Sections 4.7 and 4.8 as appropriate. Table H-1 presents the sequential transfer route number (STRN), origin of flush, destination of flush, and associated flush volume. In most cases, an origin of flush is associated with multiple destinations of flushes as the results of dead legs and piping configurations. The G2 model assumes that flushing takes place instantly.

Table H-1 HPAV and Plugging Line Flush Volumes

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
CXP-43	CXP-VSL-00026A	CXP-VSL-00026A	73.89
CXP-43	same	TLP-SEP-00001	15.37
CXP-43	same	TCP-VSL-00001	56.31
CXP-44	CXP-VSL-00026B	CXP-VSL-00026B	84.66
CXP-44	same	TLP-SEP-00001	15.37
CXP-44	same	TCP-VSL-00001	56.31
CXP-45	CXP-VSL-00026C	CXP-VSL-00026C	65.18
CXP-45	same	TLP-SEP-00001	15.37
CXP-45	same	TCP-VSL-00001	56.31
FEP-02	FEP-VSL-00017A	FEP-VSL-00017A	64.25
FEP-04	FEP-VSL-00017A	FEP-SEP-00001A	39.99
FEP-04	same	FEP-VSL-00017A	33.77
FEP-04	same	FRP-VSL-00002A	55.79
FEP-04	same	FEP-SEP-00001B	18.23
FEP-07	FEP-VSL-00017A	FEP-SEP-00001B	40.64
FEP-07	same	FEP-VSL-00017A	30.63
FEP-07	same	FEP-SEP-00001A	11.44
FEP-07	same	FRP-VSL-00002A	54.97
FEP-10	FEP-VSL-00017B	FEP-VSL-00017B	65.36
FEP-12	FEP-VSL-00017B	FEP-SEP-00001A	39.06
FEP-12	same	FEP-VSL-00017B	35.40
FEP-12	same	FEP-SEP-00001B	15.51
FEP-12	same	FRP-VSL-00002A	53.40
FEP-15	FEP-VSL-00017B	FEP-SEP-00001B	47.68
FEP-15	same	FEP-VSL-00017B	30.63
FEP-15	same	FEP-SEP-00001A	11.44
FEP-15	same	FRP-VSL-00002A	54.97
FEP-17	FEP-SEP-00001A	UFP-VSL-00001A	34.93
FEP-17	same	UFP-VSL-00001B	14.96
FEP-17	same	FRP-VSL-00002A	53.10

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
FEP-18	FEP-SEP-00001A	UFP-VSL-00001B	38.85
FEP-18	same	UFP-VSL-00001B	11.83
FEP-18	same	FRP-VSL-00002A	53.10
FEP-20	FEP-SEP-00001B	UFP-VSL-00001A	37.99
FEP-20	same	UFP-VSL-00001B	10.84
FEP-20	same	FRP-VSL-00002A	50.57
FEP-21	FEP-SEP-00001B	UFP-VSL-00001B	42.04
FEP-21	same	UFP-VSL-00001A	7.59
FEP-21	same	FRP-VSL-00002A	50.57
FRP-01	FRP-VSL-00002A	FEP-VSL-00017A	228.79
FRP-01	same	FEP-VSL-00017B	139.54
FRP-01	same	UFP-VSL-00001A	156.12
FRP-01	same	UFP-VSL-00001B	158.19
FRP-01	same	FRP-VSL-00002B	73.45
FRP-02	FRP-VSL-00002A	FEP-VSL-00017B	255.27
FRP-02	same	FEP-VSL-00017A	118.36
FRP-02	same	UFP-VSL-00001A	156.12
FRP-02	same	UFP-VSL-00001B	158.19
FRP-02	same	FRP-VSL-00002B	73.45
FRP-03	FRP-VSL-00002A	UFP-VSL-00001A	276.00
FRP-03	same	FEP-VSL-00017A	118.36
FRP-03	same	FEP-VSL-00017B	139.54
FRP-03	same	UFP-VSL-00001B	158.19
FRP-03	same	FRP-VSL-00002B	73.45
FRP-04	FRP-VSL-00002A	UFP-VSL-00001B	278.59
FRP-04	same	FEP-VSL-00017A	118.36
FRP-04	same	FEP-VSL-00017B	139.54
FRP-04	same	UFP-VSL-00001A	156.12
FRP-04	same	FRP-VSL-00002B	73.45
FRP-05	FRP-VSL-00002B	FEP-VSL-00017A	261.26
FRP-05	same	FEP-VSL-00017B	139.77
FRP-05	same	UFP-VSL-00001A	156.35
FRP-05	same	UFP-VSL-00001B	158.42
FRP-05	same	FRP-VSL-00002B	73.45
FRP-06	FRP-VSL-00002B	FEP-VSL-00017B	259.53
FRP-06	same	FEP-VSL-00017A	141.15
FRP-06	same	UFP-VSL-00001A	156.35
FRP-06	same	UFP-VSL-00001B	158.42
FRP-06	same	FRP-VSL-00002B	73.45
FRP-07	FRP-VSL-00002B	UFP-VSL-00001A	280.25
FRP-07	same	FEP-VSL-00017A	141.15
FRP-07	same	FEP-VSL-00017B	139.77
FRP-07	same	UFP-VSL-00001B	158.42
FRP-07	same	FRP-VSL-00002B	73.45
FRP-08	FRP-VSL-00002B	UFP-VSL-00001B	282.84

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
FRP-08	same	FEP-VSL-00017A	141.15
FRP-08	same	FEP-VSL-00017B	139.77
FRP-08	same	UFP-VSL-00001A	156.35
FRP-08	same	FRP-VSL-00002C	73.45
FRP-09	FRP-VSL-00002C	FEP-VSL-00017A	245.10
FRP-09	same	FEP-VSL-00017B	139.54
FRP-09	same	UFP-VSL-00001A	156.12
FRP-09	same	UFP-VSL-00001B	158.19
FRP-09	same	FRP-VSL-00002C	73.45
FRP-10	FRP-VSL-00002C	FEP-VSL-00017B	243.37
FRP-10	same	FEP-VSL-00017A	140.92
FRP-10	same	UFP-VSL-00001A	156.12
FRP-10	same	UFP-VSL-00001B	158.19
FRP-10	same	FRP-VSL-00002C	73.45
FRP-11	FRP-VSL-00002C	UFP-VSL-00001A	264.09
FRP-11	same	FEP-VSL-00017A	140.92
FRP-11	same	FEP-VSL-00017B	139.54
FRP-11	same	UFP-VSL-00001B	158.19
FRP-11	same	FRP-VSL-00002C	73.45
FRP-12	FRP-VSL-00002C	UFP-VSL-00001B	266.68
FRP-12	same	FEP-VSL-00017A	140.92
FRP-12	same	FEP-VSL-00017B	139.54
FRP-12	same	UFP-VSL-00001A	156.12
FRP-12	same	FRP-VSL-00002C	73.45
FRP-13	FRP-VSL-00002D	FEP-VSL-00017A	296.68
FRP-13	same	FEP-VSL-00017B	139.54
FRP-13	same	UFP-VSL-00001A	156.12
FRP-13	same	UFP-VSL-00001B	158.19
FRP-13	same	FRP-VSL-00002C	73.45
FRP-14	FRP-VSL-00002D	FEP-VSL-00017B	294.95
FRP-14	same	FEP-VSL-00017A	140.92
FRP-14	same	UFP-VSL-00001A	156.12
FRP-14	same	UFP-VSL-00001B	158.19
FRP-14	same	FRP-VSL-00002C	73.45
FRP-15	FRP-VSL-00002D	UFP-VSL-00001A	315.68
FRP-15	same	FEP-VSL-00017A	140.92
FRP-15	same	FEP-VSL-00017B	139.54
FRP-15	same	UFP-VSL-00001B	158.19
FRP-15	same	FRP-VSL-00002C	73.45
FRP-16	FRP-VSL-00002D	UFP-VSL-00001B	318.27
FRP-16	same	FEP-VSL-00017A	140.92
FRP-16	same	FEP-VSL-00017B	139.54
FRP-16	same	UFP-VSL-00001A	156.12
FRP-16	same	FRP-VSL-00002C	73.45
FRP-17	FRP-VSL-00002A	FRP-VSL-00002B	172.66

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
FRP-19	FRP-VSL-00002B	FRP-VSL-00002B	155.80
FRP-21	FRP-VSL-00002C	FRP-VSL-00002C	158.28
FRP-23	FRP-VSL-00002D	FRP-VSL-00002C	208.87
FRP-41	Tank-Farm-HLW	HLP-VSL-000022	254.33
FRP-41	same	FRP-VSL-00002D	138.18
FRP-41	same	FRP-VSL-00002C	40.77
FRP-41	same	FRP-VSL-00002B	52.71
FRP-41	same	FRP-VSL-00002A	56.41
FRP-44	Tank-Farm-LAW	FRP-VSL-00002A	283.70
FRP-44	same	HLP-VSL-000022	96.56
FRP-44	same	FRP-VSL-00002D	53.53
FRP-44	same	FRP-VSL-00002C	31.71
FRP-44	same	FRP-VSL-00002B	43.65
FRP-45	Tank-Farm-LAW	FRP-VSL-00002B	279.07
FRP-45	same	HLP-VSL-000022	96.56
FRP-45	same	FRP-VSL-00002D	53.53
FRP-45	same	FRP-VSL-00002C	31.71
FRP-45	same	FRP-VSL-00002A	47.36
FRP-46	Tank-Farm-LAW	FRP-VSL-00002C	264.14
FRP-46	same	HLP-VSL-000022	96.56
FRP-46	same	FRP-VSL-00002D	53.53
FRP-46	same	FRP-VSL-00002B	43.65
FRP-46	same	FRP-VSL-00002A	47.36
FRP-47	Tank-Farm-LAW	FRP-VSL-00002D	291.42
FRP-47	same	HLP-VSL-000022	96.56
FRP-47	same	FRP-VSL-00002C	31.71
FRP-47	same	FRP-VSL-00002B	43.65
FRP-47	same	FRP-VSL-00002A	47.36
HLP-02	HLP-VSL-000022	HLP-VSL-000022	262.79
HLP-03	HLP-VSL-000022	UFP-VSL-00001A	211.27
HLP-03	same	HLP-VSL-000022	67.70
HLP-03	same	HLP-VSL-000022	72.53
HLP-03	same	UFP-VSL-00001B	133.32
HLP-03	same	FEP-VSL-00017A	159.11
HLP-03	same	FEP-VSL-00017B	127.11
HLP-03	same	FRP-VSL-00002A	315.04
HLP-04	HLP-VSL-000022	UFP-VSL-00001B	210.40
HLP-04	same	HLP-VSL-000022	67.70
HLP-04	same	HLP-VSL-000022	72.53
HLP-04	same	UFP-VSL-00001A	134.01
HLP-04	same	FEP-VSL-00017A	159.11
HLP-04	same	FEP-VSL-00017B	127.11
HLP-04	same	FRP-VSL-00002A	315.04
HLP-05	HLP-VSL-000022	FEP-VSL-00017A	242.64
HLP-05	same	HLP-VSL-000022	67.70

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
HLP-05	same	HLP-VSL-00022	72.53
HLP-05	same	UFP-VSL-00001A	134.01
HLP-05	same	UFP-VSL-00001B	133.32
HLP-05	same	FEP-VSL-00017B	127.11
HLP-05	same	FRP-VSL-00002A	315.04
HLP-06	HLP-VSL-00022	FEP-VSL-00017B	202.63
HLP-06	same	HLP-VSL-00022	67.70
HLP-06	same	HLP-VSL-00022	72.53
HLP-06	same	UFP-VSL-00001A	134.01
HLP-06	same	UFP-VSL-00001B	133.32
HLP-06	same	FEP-VSL-00017A	159.11
HLP-06	same	FRP-VSL-00002A	315.04
HLP-11	HLP-VSL-00028	HLP-VSL-00028	326.91
HLP-13	HLP-VSL-00028	HFP-VSL-00005	1.00
HLP-13	same	HLP-VSL-00028	51.64
HLP-13	same	HLP-VSL-00028	88.31
HLP-13	same	PWD-VSL-00043	923.91
HLP-15	HLP-VSL-00028	HFP-VSL-00001	1.00
HLP-15	same	HLP-VSL-00028	51.64
HLP-15	same	HLP-VSL-00028	88.31
HLP-15	same	PWD-VSL-00043	905.64
HLP-20	HLP-VSL-00027A	HLP-VSL-00027A	300.61
HLP-22	HLP-VSL-00027A	HLP-VSL-00028	144.43
HLP-22	same	HLP-VSL-00027A	93.55
HLP-22	same	HLP-VSL-00027A	48.64
HLP-22	same	HLP-VSL-00027B	23.70
HLP-22	same	PWD-VSL-00033	30.71
HLP-24	HLP-VSL-00027B	HLP-VSL-00027B	245.31
HLP-26	HLP-VSL-00027B	HLP-VSL-00028	119.72
HLP-26	same	HLP-VSL-00027B	91.05
HLP-26	same	HLP-VSL-00027B	40.66
HLP-26	same	HLP-VSL-00027A	45.65
HLP-26	same	PWD-VSL-00033	30.71
RDP-21	RDP-VSL-00002B	RDP-VSL-00002B	431.74
TCP-03	TCP-VSL-00001	LCP-VSL-00001	642.60
TCP-03	same	PWD-VSL-00033	495.00
TCP-03	same	TLP-VSL-00009A	50.43
TCP-03	same	TLP-VSL-00009B	58.22
TCP-03	same	TCP-VSL-00001	122.42
TCP-04	TCP-VSL-00001	LCP-VSL-00002	664.10
TCP-04	same	PWD-VSL-00033	495.00
TCP-04	same	TLP-VSL-00009A	43.60
TCP-04	same	TLP-VSL-00009B	51.39
TCP-04	same	TCP-VSL-00001	111.83
TLP-07	TLP-VSL-00009A	TLP-VSL-00009A	74.76

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
TLP-08	TLP-VSL-00009B	TLP-VSL-00009A	77.87
TLP-10	TLP-SEP-00001	TCP-VSL-00001	86.36
UFP-02	UFP-VSL-00001A	UFP-VSL-00001A	139.21
UFP-05	UFP-VSL-00001A	UFP-VSL-00002B	96.76
UFP-05	same	UFP-VSL-00001A	26.41
UFP-05	same	UFP-VSL-00001A	65.78
UFP-05	same	FEP-VSL-00017B	50.28
UFP-05	same	FEP-VSL-00017A	63.02
UFP-05	same	UFP-VSL-00002A	54.96
UFP-06	UFP-VSL-00001A	UFP-VSL-00002A	80.69
UFP-06	same	UFP-VSL-00001A	26.41
UFP-06	same	UFP-VSL-00001A	65.78
UFP-06	same	FEP-VSL-00017B	50.28
UFP-06	same	FEP-VSL-00017A	63.02
UFP-06	same	UFP-VSL-00002B	67.81
UFP-08	UFP-VSL-00001B	UFP-VSL-00001B	220.72
UFP-11	UFP-VSL-00001B	UFP-VSL-00002B	152.79
UFP-11	same	UFP-VSL-00001B	36.07
UFP-11	same	UFP-VSL-00001B	104.96
UFP-11	same	FEP-VSL-00017B	87.85
UFP-11	same	FEP-VSL-00017A	100.59
UFP-11	same	UFP-VSL-00002A	90.23
UFP-12	UFP-VSL-00001B	UFP-VSL-00002A	134.99
UFP-12	same	UFP-VSL-00001B	36.07
UFP-12	same	UFP-VSL-00001B	104.96
UFP-12	same	FEP-VSL-00017B	87.85
UFP-12	same	FEP-VSL-00017A	100.59
UFP-12	same	UFP-VSL-00002B	104.46
UFP-13 ^{a)}	UFP-VSL-00002A	PWD-VSL-00043	0.00
UFP-13	same	UFP-VSL-00002A	0.00
UFP-13	same	HLP-VSL-00027A	0.00
UFP-15 ^{a)}	UFP-VSL-00002A	HLP-VSL-00027A	126.90
UFP-15	same	UFP-VSL-00002A	152.25
UFP-15	same	UFP-VSL-00002A	1,520.30
UFP-15	same	HLP-VSL-00027B	202.60
UFP-15	same	HLP-VSL-00028	186.92
UFP-16 ^{a)}	UFP-VSL-00002A	HLP-VSL-00027B	103.30
UFP-16	same	UFP-VSL-00002A	152.25
UFP-16	same	UFP-VSL-00002A	1,520.30
UFP-16	same	HLP-VSL-00027A	220.64
UFP-16	same	HLP-VSL-00028	202.60
UFP-18 ^{a)}	UFP-VSL-00002B	PWD-VSL-00043	0.00
UFP-18	same	UFP-VSL-00002B	0.00
UFP-18	same	HLP-VSL-00027A	0.00
UFP-20 ^{a)}	UFP-VSL-00002B	HLP-VSL-00027A	126.90

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
UFP-20	same	UFP-VSL-00002B	114.22
UFP-20	same	UFP-VSL-00002B	1,552.25
UFP-20	same	HLP-VSL-00027B	192.02
UFP-20	same	HLP-VSL-00028	174.85
UFP-21 ^{a)}	UFP-VSL-00002B	HLP-VSL-00027B	103.30
UFP-21	same	UFP-VSL-00002B	114.22
UFP-21	same	UFP-VSL-00002B	1,552.25
UFP-21	same	HLP-VSL-00027A	211.56
UFP-21	same	HLP-VSL-00028	174.85
HLW-04	HFP-VSL-00001	HFP-VSL-00002	7.72
HLW-06	HFP-VSL-00001	HFP-VSL-00001	29.70
HLW-17	HFP-VSL-00005	HFP-VSL-00006	6.62
HLW-19	HFP-VSL-00005	HFP-VSL-00005	13.43
HLW-29	HOP-SCB-00001	RLD-VSL-00007	36.35
HLW-35	HOP-VSL-00903	RLD-VSL-00007	64.76
HLW-37	HOP-HEME-00001	HOP-VSL-00903	26.77
HLW-39	HOP-SCB-00002	RLD-VSL-00007	35.94
HLW-44	HOP-VSL-00904	RLD-VSL-00007	79.85
HLW-47	HOP-HEME-00002	HOP-VSL-00904	12.55
HLW-51	RLD-VSL-00007	PWD-VSL-00043	119.09
HLW-55	RLD-VSL-00007	RLD-VSL-00007	29.46
HLW-81	HDH-VSL-00003	RLD-VSL-00007	94.55
HLW-85	HDH-VSL-00001	HDH-VSL-00003	34.94
LCP-1	LCP-VSL-00001	LCP-VSL-00001	28.00
LCP-2	LCP-VSL-00002	LCP-VSL-00002	43.00
LFP-1	LCP-VSL-00001	LFP-VSL-00001	15.00
LFP-1	same	LCP-VSL-00001	10.00
LFP-2	LCP-VSL-00001	LFP-VSL-00003	26.00
LFP-2	same	LCP-VSL-00001	10.00
LFP-3	LCP-VSL-00002	LFP-VSL-00001	11.00
LFP-3	same	LCP-VSL-00002	10.00
LFP-4	LCP-VSL-00002	LFP-VSL-00003	16.00
LFP-4	same	LCP-VSL-00002	10.00
LFP-5	LFP-VSL-00001	LFP-VSL-00001	79.00
LFP-6	LFP-VSL-00003	LFP-VSL-00003	111.00
LFP-7	LFP-VSL-00001	LFP-VSL-00002	18.00
LFP-7	same	LFP-VSL-00001	27.00
LFP-8	LFP-VSL-00003	LFP-VSL-00004	18.00
LFP-8	same	LFP-VSL-00003	28.00
LFP-9	LFP-VSL-00002	LMP-MLTR-00001	6.00
LFP-9	same	LFP-VSL-00002	12.00
LFP-10	LFP-VSL-00004	LMP-MLTR-00002	6.00
LFP-10	same	LFP-VSL-00004	12.00
LFP-11	LFP-VSL-00002	LMP-MLTR-00001	6.00
LFP-12	LFP-VSL-00004	LMP-MLTR-00002	6.00

STRN	Origin of Flush	Destination of Flush	Flush Volume (Gal)
HLP27A ^{b)}	FEP-SEP-00001A	HLP-VSL-00027A	130.00
FRP2A ^{b)}	FEP-SEP-00001A	FRP-VSL-00002A	130.00
UFP1 ^{b)}	HLP-VSL-00027A	UFP-VSL-00001A	200.00
UFP1 ^{b)}	HLP-VSL-00027A	UFP-VSL-00001B	200.00

Notes:

^{a)} The transfer line flushes have been replaced by the power flush, positive displacement pump forward feeding, and circulation loop draining operations discussed in Section 4.8.3.

^{b)} Reserved line flush operations for upfront leaching flowsheet.

Appendix I

Feed Vector Charge Balance

Appendix I

Feed Vector Charge Balance

Tank Farm supplied feed vectors must be charge balanced before they can be applied to the Dynamic (G2) Model. The feed vector component arrays must also be expanded to account for the new components used for charge balancing and also for other components specific to the WTP operations. Table I-1 provides a side-by-side comparison of the liquid/solid components given by the Tank Farm and utilized in the G2 Model.

The charge balance operations include: 1) converting all liquid phase Al^{+3} to aluminate, 2) converting leachable solid phase Al^{+3} to gibbsite, and 3) converting unleachable solid phase PO_4^{3-} to PO_4^{3-} (HARD). Liquid phase aluminum exists in the form of aluminate and therefore all the Al^{+3} (l) in the feed vector are converted to aluminate according to the following reaction:

If liquid phase $OH(Bound)$ is limiting, liquid phase CO_3^{2-} , NO_2^- , and NO_3^- will be used to substitute the deficit part of the $OH(Bound)$. The anions for substitution will be consumed in the order specified above. Unlike the other anions used for charge balancing, CO_3^{2-} carries two negative charges, which means that 2 kg-moles of CO_3^{2-} will convert 1 kg-mole of Al^{+3} .

The leachable part of the Al^{+3} (s) in the feed vector is converted to gibbsite according to the following reaction:

If solid phase $OH(Bound)$ is limiting, the deficit amount will be added forcefully. It shall be noted that the charge balance operations may cause the overall mass to alter, which has typically been insignificant.

All HLW batch clusters that are greater than 10 wt% solids by mass are diluted with preceding or succeeding LAW batches to 10 wt%. The new leach factors for each modified batch are the weighted average by total solids mass between the original HLW batch and the portion of the LAW batch(es) added. Each LAW batch is delivered with whatever volume is left after diluting HLW batches.

Table I-1 Comparison of Feed Vector Components

Tank Farm Components	Dynamic (G2) Model Components
106-Ru	106-Ru
113m-Cd	113m-Cd
125-Sb	125-Sb
126-Sn	126-Sn
129-I	129-I
134-Cs	134-Cs
137-Cs	137-Cs
137m-Ba	137m-Ba
14-C	14-C
151-Sm	151-Sm
152-Eu	152-Eu
154-Eu	154-Eu

Tank Farm Components	Dynamic (G2) Model Components
155-Eu	155-Eu
226-Ra	226-Ra
227-Ac	227-Ac
228-Ra	228-Ra
229-Th	229-Th
231-Pa	231-Pa
232-Th	232-Th
232-U	232-U
233-U	233-U
234-U	234-U
235-U	235-U
236-U	236-U
237-Np	237-Np
238-Pu	238-Pu
238-U	238-U
239-Pu	239-Pu
240-Pu	240-Pu
241-Am	241-Am
241-Pu	241-Pu
242-Cm	242-Cm
242-Pu	242-Pu
243-Am	243-Am
243-Cm	243-Cm
244-Cm	244-Cm
3-H	3-H
59-Ni	59-Ni
60-Co	60-Co
63-Ni	63-Ni
79-Se	79-Se
90-Sr	90-Sr
90-Y	90-Y
93-Zr	93-Zr
93m-Nb	93m-Nb
99-Tc	99-Tc
Ag ⁺	Ag ⁺
Al(OH) ₄ ⁻	Al(OH) ₄ ⁻
Al ⁺³	Al ⁺³
As ⁺⁵	As ⁺⁵
B ⁺³	B ⁺³
Ba ⁺²	Ba ⁺²
Be ⁺²	Be ⁺²
Bi ⁺³	Bi ⁺³
C ₁₀ H ₁₂ N ₂ O ₈ -4	C ₁₀ H ₁₂ N ₂ O ₈ -4
C ₁₀ H ₁₅ N ₂ O ₇ -3	C ₁₀ H ₁₅ N ₂ O ₇ -3
C ₁₂ H ₂₇ O ₄ P	C ₁₂ H ₂₇ O ₄ P
C ₁₃ H ₂₈	C ₁₃ H ₂₈
C ₂ Cl ₄	C ₂ Cl ₄
C ₂ H ₃ O ₂ ⁻	C ₂ H ₃ O ₂ ⁻

Tank Farm Components	Dynamic (G2) Model Components
C2H3O3-	C2H3O3-
C2HCl3	C2HCl3
C2O4-2	C2O4-2
C3H6O	C3H6O
C4H10O	C4H10O
C4H8O	C4H8O
C5H5N	C5H5N
C6H5NO2	C6H5NO2
C6H5O7-3	C6H5O7-3
C6H6	C6H6
C7H6N2O4	C7H6N2O4
C7H8O	C7H8O
Ca+2	Ca+2
Cd+2	Cd+2
Ce+3	Ce+3
CH2Cl2	CH2Cl2
CHCl3	CHCl3
CHO2-	CHO2-
Cl-	Cl-
CN-	CN-
Co+3	Co+3
CO3-2	CO3-2
Cr(OH)4-	Cr(OH)4-
Cr(TOTAL)	Cr(TOTAL)
Cs+	Cs+
Cu+2	Cu+2
F-	F-
Fe+3	Fe+3
H+	H+
H2O	H2O
H2O2	H2O2
Hg+2	Hg+2
K+	K+
La+3	La+3
Li+	Li+
Mg+2	Mg+2
Mn+4	Mn+4
MnO2	MnO2
MnO4-	MnO4-
Mo+6	Mo+6
Na+	Na+
Nd+3	Nd+3
NH3	NH3
NH4+	Ni+2
Ni+2	NO2-
NO2-	NO3-
NO3-	OH(BOUND)
O(BOUND)	OH-

Tank Farm Components	Dynamic (G2) Model Components
OH(BOUND)	Pb+2
OH-	Pd+2
Pb+2	PO4-3
Pd+2	Pr+3
PO4-3	Pu+4
Pr+3	Rb+
Pu+4	Rh+3
Rb+	Ru+3
Rh+3	Sb+5
Ru+3	Se+6
Sb+5	Si+4
Se+6	SO4-2
Si+4	Sr+2
SO4-2	Ta+5
Sr+2	Tc+7
Ta+5	Te+6
Tc+7	Th+4
Te+6	Ti+4
Th+4	Tl+3
Ti+4	TOC
Tl+3	U(TOTAL)
TOC	V+5
U(TOTAL)	W+6
V+5	Y+3
W+6	Zn+2
Y+3	Zr+4
Zn+2	C10H8
Zr+4	C12H4Cl6
	C12H8
	C2H3N
	C2H6SiO
	C2H8N2
	H2O(BOUND)
	C4H7NO4
	C6H6O
	C7H8
	C8H8O
	CCl4
	H2CO3
	HCO3-
	Mnp
	Nap+
	NH4+
	O-2
	Al(OH)3
	PO4-3(HARD)
	PPG
	DPPG

Tank Farm Components	Dynamic (G2) Model Components
	PDMS
	DPDMS
	NO3-D
	AlOOH
	LS9
	LS10

Appendix J

Mass Balance Flowsheet Diagrams and Volume Throughput

Appendix J

Mass Balance Flowsheet Diagrams and Volume Throughput

Simplified mass balance flowsheet diagrams are developed to support flowsheet developments and model validations. These diagrams present the cumulative masses for process streams on the systems level. The diagrams are presented in four Excel spreadsheets, namely: PT-1, PT-2, LAW, and HLW as shown in Figures J-1 through J-4. Types of mass balance and flowsheet diagrams include: Total Mass, Total Volume, Radioactivity, Aluminum, Chromium, Iron, Sodium, Oxalate, Cesium 137, Strontium 90, Iodine 129, Technetium 99, Mercury, Water, AFA, and Phosphate. The mass balance is obtained using the G2 totalizer data for process streams into and out of the systems. Table J-1 shows the totalizer files and associated systems, stream names, stream numbers, and waste types. The Visual C# routine "G2MBC" is used to perform the calculations. Source codes of the G2MBC are presented in Table J-2. Similarities and differences between the totalizer files in Tables J-1 and N-1 shall be distinguished. Table J-1 provides the totalizer files for process streams on the systems level such that internal streams are excluded. Table N-1 lists the totalizer files for every process streams in the flowsheet including those internal.

In addition to the mass balance flowsheet diagrams above, volume throughputs for some key unit operations are also of particular interests in performance analysis. These volume throughputs are extracted from G2 totalizer files for the process streams specified in the input using the Visual C# routine "TVExtractor". Table J-3 shows the results of an example application where process condensate utilization by various unit operations are summarized. Source codes of the TVExtractor are presented in Table J-4.

Figure J-1 Mass Balance Flowsheet Diagram (PT-1)

Figure J-2 Mass Balance Flowsheet Diagram (PT-2)

Figure J-3 Mass Balance Flowsheet Diagram (LAW)

Figure J-4 Mass Balance Flowsheet Diagram (HLW)

Table J-1 Flowsheet Diagram Stream Makeup File

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
FRP	TankFarm_FRP	1	TANK-FARM-LAW_FRP-VSL-00002A.csv	Waste
FRP	TankFarm_FRP	1	TANK-FARM-LAW_FRP-VSL-00002B.csv	Waste
FRP	TankFarm_FRP	1	TANK-FARM-LAW_FRP-VSL-00002C.csv	Waste
FRP	TankFarm_FRP	1	TANK-FARM-LAW_FRP-VSL-00002D.csv	Waste
FRP	ChemAdd_FRP	2	DIW-TK-00001_FRP-VSL-00002A.csv	ChemAdd
FRP	ChemAdd_FRP	2	DIW-TK-00001_FRP-VSL-00002B.csv	ChemAdd
FRP	ChemAdd_FRP	2	DIW-TK-00001_FRP-VSL-00002C.csv	ChemAdd
FRP	ChemAdd_FRP	2	DIW-TK-00001_FRP-VSL-00002D.csv	ChemAdd
FRP	ChemAdd_FRP	2	INHIBITED-WATER_FRP-VSL-00002A.csv	ChemAdd
FRP	ChemAdd_FRP	2	INHIBITED-WATER_FRP-VSL-00002B.csv	ChemAdd
FRP	ChemAdd_FRP	2	INHIBITED-WATER_FRP-VSL-00002C.csv	ChemAdd
FRP	ChemAdd_FRP	2	INHIBITED-WATER_FRP-VSL-00002D.csv	ChemAdd
FRP	ChemAdd_FRP	2	PSA_FRP-VSL-00002A.csv	ChemAdd
FRP	ChemAdd_FRP	2	PSA_FRP-VSL-00002B.csv	ChemAdd
FRP	ChemAdd_FRP	2	PSA_FRP-VSL-00002C.csv	ChemAdd
FRP	ChemAdd_FRP	2	PSA_FRP-VSL-00002D.csv	ChemAdd
FRP	ChemAdd_FRP	2	RFD-AIR_FRP-VSL-00002A.csv	ChemAdd
FRP	ChemAdd_FRP	2	RFD-AIR_FRP-VSL-00002B.csv	ChemAdd
FRP	ChemAdd_FRP	2	RFD-AIR_FRP-VSL-00002C.csv	ChemAdd
FRP	ChemAdd_FRP	2	RFD-AIR_FRP-VSL-00002D.csv	ChemAdd
FRP	ChemAdd_FRP	2	RLD-TK-00006A_FRP-VSL-00002A.csv	ChemAdd
FRP	ChemAdd_FRP	2	RLD-TK-00006A_FRP-VSL-00002B.csv	ChemAdd
FRP	ChemAdd_FRP	2	RLD-TK-00006A_FRP-VSL-00002C.csv	ChemAdd
FRP	ChemAdd_FRP	2	RLD-TK-00006A_FRP-VSL-00002D.csv	ChemAdd
HLP22	TankFarm_HLP22	3	TANK-FARM-HLW_HLP-VSL-00022.csv	Waste
HLP22	ChemAdd_HLP22	4	DIW-TK-00001_HLP-VSL-00022.csv	ChemAdd
HLP22	ChemAdd_HLP22	4	INHIBITED-WATER_HLP-VSL-00022.csv	ChemAdd
HLP22	ChemAdd_HLP22	4	PSA_HLP-VSL-00022.csv	ChemAdd
HLP22	ChemAdd_HLP22	4	RFD-AIR_HLP-VSL-00022.csv	ChemAdd
HLP22	ChemAdd_HLP22	4	RLD-TK-00006A_HLP-VSL-00022.csv	ChemAdd
FEP	FRP_FEP	5	FRP-VSL-00002A_FEP-VSL-00017A.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002A_FEP-VSL-00017B.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002B_FEP-VSL-00017A.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002B_FEP-VSL-00017B.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002C_FEP-VSL-00017A.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002C_FEP-VSL-00017B.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002D_FEP-VSL-00017A.csv	Waste
FEP	FRP_FEP	5	FRP-VSL-00002D_FEP-VSL-00017B.csv	Waste
HLP22	FRP_HLP22	6	FRP-VSL-00002A_HLP-VSL-00022.csv	Waste
HLP22	FRP_HLP22	6	FRP-VSL-00002B_HLP-VSL-00022.csv	Waste
HLP22	FRP_HLP22	6	FRP-VSL-00002C_HLP-VSL-00022.csv	Waste
HLP22	FRP_HLP22	6	FRP-VSL-00002D_HLP-VSL-00022.csv	Waste
FEP	PWD_FEP	7	PWD-VSL-00015_FEP-VSL-00017A.csv	Recycle
FEP	PWD_FEP	7	PWD-VSL-00015_FEP-VSL-00017B.csv	Recycle
FEP	PWD_FEP	7	PWD-VSL-00016_FEP-VSL-00017A.csv	Recycle

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
FEP	PWD_FEP	7	PWD-VSL-00016_FEP-VSL-00017B.csv	Recycle
FEP	PWD_FEP	7	PWD-VSL-00044_FEP-VSL-00017A.csv	Recycle
FEP	PWD_FEP	7	PWD-VSL-00044_FEP-VSL-00017B.csv	Recycle
FEP	ProCond_FEP	8	RLD-TK-00006A_FEP-SEP-00001A.csv	ProCond
FEP	ProCond_FEP	8	RLD-TK-00006A_FEP-SEP-00001B.csv	ProCond
FEP	ProCond_FEP	8	RLD-TK-00006A_FEP-VSL-00017A.csv	ProCond
FEP	ProCond_FEP	8	RLD-TK-00006A_FEP-VSL-00017B.csv	ProCond
FEP	RDP_FEP	9	RDP-VSL-00002B_FEP-VSL-00017A.csv	Waste
FEP	RDP_FEP	9	RDP-VSL-00002B_FEP-VSL-00017B.csv	Waste
FEP	RDP_FEP	9	RDP-VSL-00002C_FEP-VSL-00017A.csv	Waste
FEP	RDP_FEP	9	RDP-VSL-00002C_FEP-VSL-00017B.csv	Waste
FEP	ChemAdd_FEP	10	ANTIFOAM-AGENT_FEP-SEP-00001A.csv	ChemAdd
FEP	ChemAdd_FEP	10	ANTIFOAM-AGENT_FEP-SEP-00001B.csv	ChemAdd
FEP	ChemAdd_FEP	10	DIW-TK-00001_FEP-SEP-00001A.csv	ChemAdd
FEP	ChemAdd_FEP	10	DIW-TK-00001_FEP-SEP-00001B.csv	ChemAdd
FEP	ChemAdd_FEP	10	DIW-TK-00001_FEP-VSL-00017A.csv	ChemAdd
FEP	ChemAdd_FEP	10	DIW-TK-00001_FEP-VSL-00017B.csv	ChemAdd
FEP	ChemAdd_FEP	10	FEPA-INTER-AFTER-CONDENSER-WATER_FEP-VSL-00005A.csv	ChemAdd
FEP	ChemAdd_FEP	10	FEPB-INTER-AFTER-CONDENSER-WATER_FEP-VSL-00005B.csv	ChemAdd
FEP	ChemAdd_FEP	10	FEP-DMST-00001A-AIR_FEP-DMST-00001A.csv	ChemAdd
FEP	ChemAdd_FEP	10	FEP-DMST-00001B-AIR_FEP-DMST-00001B.csv	ChemAdd
FEP	ChemAdd_FEP	10	PSA_FEP-VSL-00017A.csv	ChemAdd
FEP	ChemAdd_FEP	10	PSA_FEP-VSL-00017B.csv	ChemAdd
FEP	ChemAdd_FEP	10	RFD-AIR_FEP-VSL-00017A.csv	ChemAdd
FEP	ChemAdd_FEP	10	RFD-AIR_FEP-VSL-00017B.csv	ChemAdd
UFP	FEP_UFP	11	FEP-SEP-00001A_UFP-VSL-00001A.csv	Waste
UFP	FEP_UFP	11	FEP-SEP-00001A_UFP-VSL-00001B.csv	Waste
UFP	FEP_UFP	11	FEP-SEP-00001B_UFP-VSL-00001A.csv	Waste
UFP	FEP_UFP	11	FEP-SEP-00001B_UFP-VSL-00001B.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002A_UFP-VSL-00001A.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002A_UFP-VSL-00001B.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002B_UFP-VSL-00001A.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002B_UFP-VSL-00001B.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002C_UFP-VSL-00001A.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002C_UFP-VSL-00001B.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002D_UFP-VSL-00001A.csv	Waste
UFP	FRP_UFP	12	FRP-VSL-00002D_UFP-VSL-00001B.csv	Waste
UFP	HLP22_UFP	13	HLP-VSL-00022_UFP-VSL-00001A.csv	Waste
UFP	HLP22_UFP	13	HLP-VSL-00022_UFP-VSL-00001B.csv	Waste
UFP	ProCond_UFP	14	RLD-TK-00006A_UFP-VSL-00001A.csv	ProCond
UFP	ProCond_UFP	14	RLD-TK-00006A_UFP-VSL-00001B.csv	ProCond
UFP	ProCond_UFP	14	RLD-TK-00006A_UFP-VSL-00002A.csv	ProCond
UFP	ProCond_UFP	14	RLD-TK-00006A_UFP-VSL-00002B.csv	ProCond

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
UFP	ProCond_UFP	14	RLD-TK-00006A_UFP-VSL-00062A.csv	ProCond
UFP	ChemAdd_UFP	15	ANTIFOAM-AGENT_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	ANTIFOAM-AGENT_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	ANTIFOAM-AGENT_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	ANTIFOAM-AGENT_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	DIW-TK-00001_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	DIW-TK-00001_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	DIW-TK-00001_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	DIW-TK-00001_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	DIW-TK-00001_UFP-VSL-00062A.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-02A-P1.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-02A-P2.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-02B-P1.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-02B-P2.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	INHIBITED-WATER_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	NAR-TK-00006_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	NAR-TK-00006_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	NEUTRALIZATION-CAUSTIC_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	NEUTRALIZATION-CAUSTIC_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	OXIDATIVE-LEACH-CAUSTIC_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	OXIDATIVE-LEACH-CAUSTIC_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	PSA_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	PSA_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	PSA_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	PSA_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	PSA_UFP-VSL-00062A.csv	ChemAdd
UFP	ChemAdd_UFP	15	RFD-AIR_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	RFD-AIR_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	RFD-AIR_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	RFD-AIR_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	RFD-AIR_UFP-VSL-00062A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SHR-TK-00006_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SHR-TK-00006_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	SHR-TK-00006_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SHR-TK-00006_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	SHR-TK-00006_UFP-VSL-00062A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SPR-MXR-00001_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SPR-MXR-00001_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	SPR-MXR-00001_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	SPR-MXR-00001_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	STEAM_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	STEAM_UFP-VSL-00001B.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
UFP	ChemAdd_UFP	15	STEAM_UFP-VSL-00002A.csv	ChemAdd
UFP	ChemAdd_UFP	15	STEAM_UFP-VSL-00002B.csv	ChemAdd
UFP	ChemAdd_UFP	15	STEAM_UFP-VSL-00062A.csv	ChemAdd
UFP	ChemAdd_UFP	15	STR-MXR-00001_UFP-VSL-00001A.csv	ChemAdd
UFP	ChemAdd_UFP	15	STR-MXR-00001_UFP-VSL-00001B.csv	ChemAdd
UFP	ChemAdd_UFP	15	UFP-02-P2-NAOH_UFP-02A-P2.csv	ChemAdd
UFP	ChemAdd_UFP	15	UFP-02-P2-NAOH_UFP-02B-P2.csv	ChemAdd
PWD	UFP_PWD	16	UFP-02A-P2_PWD-VSL-00015.csv	Waste
PWD	UFP_PWD	16	UFP-02A-P2_PWD-VSL-00016.csv	Waste
PWD	UFP_PWD	16	UFP-02B-P2_PWD-VSL-00015.csv	Waste
PWD	UFP_PWD	16	UFP-02B-P2_PWD-VSL-00016.csv	Waste
PWD	UFP_PWD	16	UFP-02A-P2_PWD-VSL-00033.csv	Waste
PWD	UFP_PWD	16	UFP-02B-P2_PWD-VSL-00033.csv	Waste
PWD	UFP_PWD	16	UFP-VSL-00002A_PWD-VSL-00015.csv	Waste
PWD	UFP_PWD	16	UFP-VSL-00002A_PWD-VSL-00016.csv	Waste
PWD	UFP_PWD	16	UFP-VSL-00002B_PWD-VSL-00015.csv	Waste
PWD	UFP_PWD	16	UFP-VSL-00002B_PWD-VSL-00016.csv	Waste
PWD	PVP_PWD	17	PJV-VSL-00001_PWD-VSL-00043.csv	Waste
PWD	PVP_PWD	17	PVP-SCB-00002_PWD-VSL-00044.csv	Waste
PWD	PVP_PWD	17	PVP-VSL-00001_PWD-VSL-00044.csv	Waste
PWD	Recycle_PWD	18	CNP-EVAP-00001_PWD-VSL-00015.csv	Waste
PWD	Recycle_PWD	18	CNP-EVAP-00001_PWD-VSL-00016.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00001_PWD-VSL-00015.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00001_PWD-VSL-00016.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00002_PWD-VSL-00015.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00002_PWD-VSL-00016.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00003_PWD-VSL-00015.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00003_PWD-VSL-00016.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00004_PWD-VSL-00015.csv	Waste
PWD	Recycle_PWD	18	CXP-IXC-00004_PWD-VSL-00016.csv	Waste
PWD	Recycle_PWD	18	RLD-VSL-00007_PWD-VSL-00043.csv	Waste
PWD	Recycle_PWD	18	CXP-FILT-00001_PWD-VSL-00016.csv	Waste
PWD	ProCond_PWD	19	RLD-TK-00006A_PWD-VSL-00033.csv	ProCond
PWD	ProCond_PWD	19	RLD-TK-00006A_PWD-VSL-00043.csv	ProCond
PWD	ChemAdd_PWD	20	DIW-TK-00001_PWD-VSL-00033.csv	ChemAdd
PWD	ChemAdd_PWD	20	DIW-TK-00001_PWD-VSL-00043.csv	ChemAdd
PWD	ChemAdd_PWD	20	INHIBITED-WATER_PWD-VSL-00033.csv	ChemAdd
PWD	ChemAdd_PWD	20	INHIBITED-WATER_PWD-VSL-00043.csv	ChemAdd
PWD	ChemAdd_PWD	20	PSA_PWD-VSL-00015.csv	ChemAdd
PWD	ChemAdd_PWD	20	PSA_PWD-VSL-00016.csv	ChemAdd
PWD	ChemAdd_PWD	20	PSA_PWD-VSL-00033.csv	ChemAdd
PWD	ChemAdd_PWD	20	PSA_PWD-VSL-00043.csv	ChemAdd
PWD	ChemAdd_PWD	20	PSA_PWD-VSL-00044.csv	ChemAdd
PWD	ChemAdd_PWD	20	RFD-AIR_PWD-VSL-00015.csv	ChemAdd
PWD	ChemAdd_PWD	20	RFD-AIR_PWD-VSL-00016.csv	ChemAdd
PWD	ChemAdd_PWD	20	RFD-AIR_PWD-VSL-00033.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
PWD	ChemAdd_PWD	20	RFD-AIR_PWD-VSL-00043.csv	ChemAdd
PWD	ChemAdd_PWD	20	RFD-AIR_PWD-VSL-00044.csv	ChemAdd
PWD	ChemAdd_PWD	20	SHR-TK-00006_PWD-VSL-00015.csv	ChemAdd
PWD	ChemAdd_PWD	20	SHR-TK-00006_PWD-VSL-00016.csv	ChemAdd
PWD	ChemAdd_PWD	20	SHR-TK-00006_PWD-VSL-00044.csv	ChemAdd
HLP	UFP_HLP	21	UFP-VSL-00002A_HLP-VSL-00027A.csv	Waste
HLP	UFP_HLP	21	UFP-VSL-00002A_HLP-VSL-00027B.csv	Waste
HLP	UFP_HLP	21	UFP-VSL-00002B_HLP-VSL-00027A.csv	Waste
HLP	UFP_HLP	21	UFP-VSL-00002B_HLP-VSL-00027B.csv	Waste
HLP	ProCond_HLP	22	RLD-TK-00006A_HLP-VSL-00027A.csv	ProCond
HLP	ProCond_HLP	22	RLD-TK-00006A_HLP-VSL-00027B.csv	ProCond
HLP	ProCond_HLP	22	RLD-TK-00006A_HLP-VSL-00028.csv	ProCond
HLP	CNP_HLP	23	CNP-EVAP-00001_HLP-VSL-00027B.csv	Waste
HLP	CNP_HLP	23	CNP-EVAP-00001_HLP-VSL-00028.csv	Waste
HLP	CNP_HLP	23	CNP-VSL-00003_HLP-VSL-00027B.csv	Waste
HLP	CNP_HLP	23	CNP-VSL-00003_HLP-VSL-00028.csv	Waste
HLP	ChemAdd_HLP	24	ANTIFOAM-AGENT_HLP-VSL-00027A.csv	ChemAdd
HLP	ChemAdd_HLP	24	ANTIFOAM-AGENT_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	ANTIFOAM-AGENT_HLP-VSL-00028.csv	ChemAdd
HLP	ChemAdd_HLP	24	DIW-TK-00001_HLP-VSL-00027A.csv	ChemAdd
HLP	ChemAdd_HLP	24	DIW-TK-00001_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	DIW-TK-00001_HLP-VSL-00028.csv	ChemAdd
HLP	ChemAdd_HLP	24	HLP14_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	HLP14_HLP-VSL-00028.csv	ChemAdd
HLP	ChemAdd_HLP	24	INHIBITED-WATER_HLP-VSL-00027A.csv	ChemAdd
HLP	ChemAdd_HLP	24	INHIBITED-WATER_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	INHIBITED-WATER_HLP-VSL-00028.csv	ChemAdd
HLP	ChemAdd_HLP	24	PSA_HLP-VSL-00027A.csv	ChemAdd
HLP	ChemAdd_HLP	24	PSA_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	PSA_HLP-VSL-00028.csv	ChemAdd
HLP	ChemAdd_HLP	24	RFD-AIR_HLP-VSL-00027A.csv	ChemAdd
HLP	ChemAdd_HLP	24	RFD-AIR_HLP-VSL-00027B.csv	ChemAdd
HLP	ChemAdd_HLP	24	RFD-AIR_HLP-VSL-00028.csv	ChemAdd
PVP-PJV	FEP_PVP/PJV	25	FEP-DMST-00001A_PVP-VESSEL-VENT.csv	Waste
PVP-PJV	FEP_PVP/PJV	25	FEP-DMST-00001B_PVP-VESSEL-VENT.csv	Waste
PVP-PJV	TLP_PVP/PJV	26	TLP-DMST-00001_PVP-VESSEL-VENT.csv	Waste
PVP-PJV	PJM/RFD_PVP/PJV	27	CNP-VSL-00004_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	CNP-VSL-00003_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	CXP-VSL-00005_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	CXP-VSL-00026A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	CXP-VSL-00026B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	CXP-VSL-00026C_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	FEP-VSL-00017A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	FEP-VSL-00017B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	FRP-VSL-00002A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	FRP-VSL-00002B_PJM-RFD-VENT.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
PVP-PJV	PJM/RFD_PVP/PJV	27	FRP-VSL-00002C_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	FRP-VSL-00002D_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	HLP-VSL-00022_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	HLP-VSL-00027A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	HLP-VSL-00027B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	HLP-VSL-00028_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	PWD-VSL-00015_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	PWD-VSL-00016_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	PWD-VSL-00033_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	PWD-VSL-00043_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	PWD-VSL-00044_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	RDP-VSL-00002A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	RDP-VSL-00002B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	RDP-VSL-00002C_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	TCP-VSL-00001_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	TLP-VSL-00009A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	TLP-VSL-00009B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	UFP-VSL-00001A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	UFP-VSL-00001B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	UFP-VSL-00002A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	UFP-VSL-00002B_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	PJM/RFD_PVP/PJV	27	UFP-VSL-00062A_PJM-RFD-VENT.csv	ChemAdd
PVP-PJV	ChemAdd_PVP/PJV	28	AIR-VENT-LUMP-SUM_PVP-VESSEL-VENT.csv	ChemAdd
PVP-PJV	ChemAdd_PVP/PJV	28	DIW-TK-00004_PJV-VSL-00001.csv	ChemAdd
PVP-PJV	ChemAdd_PVP/PJV	28	DIW-TK-00004_PVP-HEME-00001.csv	ChemAdd
PVP-PJV	ChemAdd_PVP/PJV	28	SHR-TK-00007_PVP-SCB-00002.csv	ChemAdd
PVP-PJV	ChemAdd_PVP/PJV	28	UFV-HLP-3HR-ROTATION_PVP-VESSEL-VENT.csv	ChemAdd
PVP-PJV	PT-Stack	29	PJV-HEPA_PVP-STACK.csv	OffGas
PVP-PJV	PT-Stack	29	PVP-ABS-00001AB_PVP-STACK.csv	OffGas
CXP	UFP_CXP	30	UFP-VSL-00062A_CXP-FILT-00001.csv	Waste
CXP	RDP/CRP_CXP	31	CRP-VSL-00001_CXP-IXC-00001.csv	ChemAdd
CXP	RDP/CRP_CXP	31	CRP-VSL-00001_CXP-IXC-00002.csv	ChemAdd
CXP	RDP/CRP_CXP	31	CRP-VSL-00001_CXP-IXC-00003.csv	ChemAdd
CXP	RDP/CRP_CXP	31	CRP-VSL-00001_CXP-IXC-00004.csv	ChemAdd
CXP	RDP/CRP_CXP	31	RDP-VSL-00002A_CXP-IXC-00001.csv	ChemAdd
CXP	RDP/CRP_CXP	31	RDP-VSL-00002A_CXP-IXC-00002.csv	ChemAdd
CXP	RDP/CRP_CXP	31	RDP-VSL-00002A_CXP-IXC-00003.csv	ChemAdd
CXP	RDP/CRP_CXP	31	RDP-VSL-00002A_CXP-IXC-00004.csv	ChemAdd
CXP	CNP_CXP	32	CNP-VSL-00004_CXP-IXC-00001.csv	ChemAdd
CXP	CNP_CXP	32	CNP-VSL-00004_CXP-IXC-00002.csv	ChemAdd
CXP	CNP_CXP	32	CNP-VSL-00004_CXP-IXC-00003.csv	ChemAdd
CXP	CNP_CXP	32	CNP-VSL-00004_CXP-IXC-00004.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-1_CXP-IXC-00001.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-1_CXP-IXC-00002.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-1_CXP-IXC-00003.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-1_CXP-IXC-00004.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-2_CXP-IXC-00001.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-2_CXP-IXC-00002.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-2_CXP-IXC-00003.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-IXC-RINSE-2_CXP-IXC-00004.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-IXC-00001.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-IXC-00002.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-IXC-00003.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-IXC-00004.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-TK-00001_CXP-IXC-00001.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-TK-00001_CXP-IXC-00002.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-TK-00001_CXP-IXC-00003.csv	ChemAdd
CXP	ChemAdd_CXP	33	DIW-TK-00001_CXP-IXC-00004.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-FILT-00001.csv	ChemAdd
CXP	ChemAdd_CXP	33	PSA_CXP-VSL-00005.csv	ChemAdd
CXP	ChemAdd_CXP	33	RFD-AIR_CXP-VSL-00005.csv	ChemAdd
CXP	ChemAdd_CXP	33	SHR-TK-00005_CXP-VSL-00005.csv	ChemAdd
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00001_RDP-VSL-00002A.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00001_RDP-VSL-00002B.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00002_RDP-VSL-00002A.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00002_RDP-VSL-00002B.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00003_RDP-VSL-00002A.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00003_RDP-VSL-00002B.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00004_RDP-VSL-00002A.csv	Waste
RDP-CRP	CXP_RDP/CRP	34	CXP-IXC-00004_RDP-VSL-00002B.csv	Waste
RDP-CRP	ChemAdd_RDP/CRP	35	DIW-TK-00001_RDP-VSL-00002A.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	DIW-TK-00001_RDP-VSL-00002B.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	DIW-TK-00004_CRP-VSL-00001.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	NAR-MXR-00003_CRP-VSL-00001.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	PSA_RDP-VSL-00002A.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	PSA_RDP-VSL-00002B.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	PSA_RDP-VSL-00002C.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RDP-VSL-00002A-CAUSTIC_RDP-VSL-00002A.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RFD-AIR_RDP-VSL-00002A.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RFD-AIR_RDP-VSL-00002B.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RFD-AIR_RDP-VSL-00002C.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RF-RESIN_CRP-VSL-00001.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	RLD-TK-00006A_RDP-VSL-00002B.csv	ChemAdd
RDP-CRP	ChemAdd_RDP/CRP	35	SHR-TK-00004_CRP-VSL-00001.csv	ChemAdd
CNP	CXP_CNP	36	CXP-IXC-00001_CNP-EVAP-00001.csv	Waste
CNP	CXP_CNP	36	CXP-IXC-00002_CNP-EVAP-00001.csv	Waste
CNP	CXP_CNP	36	CXP-IXC-00003_CNP-EVAP-00001.csv	Waste
CNP	CXP_CNP	36	CXP-IXC-00004_CNP-EVAP-00001.csv	Waste
CNP	CXP_CNP	36	CNP-VSL-00004_CNP-EVAP-00001.csv	Waste

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
CNP	ChemAdd_CNP	37	NAR-TK-00005_CNP-EVAP-00001.csv	ChemAdd
CNP	ChemAdd_CNP	37	NAR-TK-00006_CNP-VSL-00004.csv	ChemAdd
CNP	ChemAdd_CNP	37	SHR-TK-00001_CNP-EVAP-00001.csv	ChemAdd
CNP	ChemAdd_CNP	37	PSA_CNP-VSL-00004.csv	ChemAdd
CNP	ChemAdd_CNP	37	PSA_CNP-VSL-00003.csv	ChemAdd
CNP	ChemAdd_CNP	37	RFD-AIR_CNP-VSL-00004.csv	ChemAdd
CNP	ChemAdd_CNP	37	RFD-AIR_CNP-VSL-00003.csv	ChemAdd
TLP	CXP_TLP	38	CXP-IXC-00001_CXP-VSL-00026A.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00001_CXP-VSL-00026B.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00001_CXP-VSL-00026C.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00002_CXP-VSL-00026A.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00002_CXP-VSL-00026B.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00002_CXP-VSL-00026C.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00003_CXP-VSL-00026A.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00003_CXP-VSL-00026B.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00003_CXP-VSL-00026C.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00004_CXP-VSL-00026A.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00004_CXP-VSL-00026B.csv	Waste
TLP	CXP_TLP	38	CXP-IXC-00004_CXP-VSL-00026C.csv	Waste
TLP	LAWRLD_TLP	39	RLD-VSL-00005_SUPPLEMENTAL-LAW-RECYCLE.csv	Waste
TLP	LAWRLD_TLP	39	RLD-VSL-00005_TLP-VSL-00009A.csv	Waste
TLP	LAWRLD_TLP	39	RLD-VSL-00005_TLP-VSL-00009B.csv	Waste
TLP	ChemAdd_TLP	40	ANTIFOAM-AGENT_TLP-SEP-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_CXP-VSL-00026A.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_CXP-VSL-00026B.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_CXP-VSL-00026C.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_SUPPLEMENTAL-LAW-RECYCLE.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_TCP-VSL-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_TLP-SEP-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_TLP-VSL-00009A.csv	ChemAdd
TLP	ChemAdd_TLP	40	DIW-TK-00001_TLP-VSL-00009B.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_CXP-VSL-00026A.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_CXP-VSL-00026B.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_CXP-VSL-00026C.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_TCP-VSL-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_TLP-VSL-00009A.csv	ChemAdd
TLP	ChemAdd_TLP	40	PSA_TLP-VSL-00009B.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_CXP-VSL-00026A.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_CXP-VSL-00026B.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_CXP-VSL-00026C.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_TCP-VSL-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_TLP-VSL-00009A.csv	ChemAdd
TLP	ChemAdd_TLP	40	RFD-AIR_TLP-VSL-00009B.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_CXP-VSL-00026A.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
TLP	ChemAdd_TLP	40	RLD-TK-00006A_CXP-VSL-00026B.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_CXP-VSL-00026C.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_SUPPLEMENTAL-LAW-RECYCLE.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_TCP-VSL-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_TLP-SEP-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_TLP-VSL-00009A.csv	ChemAdd
TLP	ChemAdd_TLP	40	RLD-TK-00006A_TLP-VSL-00009B.csv	ChemAdd
TLP	ChemAdd_TLP	40	SHR-TK-00007_TLP-VSL-00009A.csv	ChemAdd
TLP	ChemAdd_TLP	40	SHR-TK-00007_TLP-VSL-00009B.csv	ChemAdd
TLP	ChemAdd_TLP	40	TLP-DMST-00001-AIR_TLP-DMST-00001.csv	ChemAdd
TLP	ChemAdd_TLP	40	TLP-INTER-AFTER-CONDENSER-WATER_TLP-VSL-00002.csv	ChemAdd
PT-RLD	FEP_PTRLD	41	FEP-VSL-00005A_RLD-TK-00006A.csv	Waste
PT-RLD	FEP_PTRLD	41	FEP-VSL-00005B_RLD-TK-00006A.csv	Waste
PT-RLD	CRP_PTRLD	42	CRP-VSL-00001_RLD-VSL-00017A.csv	Waste
PT-RLD	CRP_PTRLD	42	CRP-VSL-00001_RLD-VSL-00017B.csv	Waste
PT-RLD	TLP_PTRLD	43	TLP-VSL-00002_RLD-TK-00006A.csv	Waste
PT-RLD	LAWRLD_PTRLD	44	LVP-TK-00001_RLD-VSL-00017A.csv	Waste
PT-RLD	LAWRLD_PTRLD	44	LVP-TK-00001_RLD-VSL-00017B.csv	Waste
PT-RLD	PtrLD ETF	45	RLD-TK-00006B ETF-1.csv	Waste
LCP-LFP	TLP_LCP	46	TCP-VSL-00001_LCP-VSL-00001.csv	Waste
LCP-LFP	TLP_LCP	46	TCP-VSL-00001_LCP-VSL-00002.csv	Waste
LCP-LFP	TLP_SupLAW	47	TCP-VSL-00001_SUPPLEMENTAL-LAW-TREATED.csv	Waste
LCP-LFP	TLP_SupLAW	47	LCP-VSL-00001_SUPPLEMENTAL-LAW-TREATED.csv	Waste
LCP-LFP	TLP_SupLAW	47	LCP-VSL-00002_SUPPLEMENTAL-LAW-TREATED.csv	Waste
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LCP-VSL-00001.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LCP-VSL-00002.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LFP-VSL-00001.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LFP-VSL-00002.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LFP-VSL-00003.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	DIW-TK-00001_LFP-VSL-00004.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	RHEOLOGY-WATER_LFP-VSL-00001.csv	ChemAdd
LCP-LFP	Water_LCP/LFP	48	RHEOLOGY-WATER_LFP-VSL-00003.csv	ChemAdd
LCP-LFP	GFormer_LFP	49	LFP-VSL-00001-MIXER_LFP-VSL-00001.csv	ChemAdd
LCP-LFP	GFormer_LFP	49	LFP-VSL-00003-MIXER_LFP-VSL-00003.csv	ChemAdd
LMP	LFP_LMP	50	LFP-VSL-00002_LMP-MLTR-00001.csv	Waste
LMP	LFP_LMP	50	LFP-VSL-00004_LMP-MLTR-00002.csv	Waste
LMP	ChemAdd_LMP	51	DIW-TK-00001_LMP-MLTR-00002.csv	ChemAdd
LMP	ChemAdd_LMP	51	DIW-TK-00001_LMP-MLTR-00001.csv	ChemAdd
LMP	ChemAdd_LMP	51	LMP-MLTR-00001-AIR_LMP-MLTR-00001.csv	ChemAdd
LMP	ChemAdd_LMP	51	LMP-MLTR-00001-WATER_LMP-MLTR-00001.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
LMP	ChemAdd_LMP	51	LMP-MLTR-00002-AIR_LMP-MLTR-00002.csv	ChemAdd
LMP	ChemAdd_LMP	51	LMP-MLTR-00002-WATER_LMP-MLTR-00002.csv	ChemAdd
LMP	LMP_ILAW	52	LMP-MLTR-00001_LAW-CONTAINERS-1.csv	ILAW
LMP	LMP_ILAW	52	LMP-MLTR-00002_LAW-CONTAINERS-2.csv	ILAW
LOP	LMP_LOP	53	LMP-MLTR-00001_LOP-SCB-00001.csv	OffGas
LOP	LMP_LOP	53	LMP-MLTR-00002_LOP-SCB-00002.csv	OffGas
LOP	ChemAdd_LOP	54	LOP09_LOP-WESP-00001.csv	ChemAdd
LOP	ChemAdd_LOP	54	LOP09_LOP-WESP-00002.csv	ChemAdd
LOP	ChemAdd_LOP	54	LOP-SCB-00001-WATER_LOP-SCB-00001.csv	ChemAdd
LOP	ChemAdd_LOP	54	LOP-SCB-00002-WATER_LOP-SCB-00002.csv	ChemAdd
LVP	LOP_LVP	55	LOP-WESP-00001_LAW-VESSEL-VENT.csv	OffGas
LVP	LOP_LVP	55	LOP-WESP-00002_LAW-VESSEL-VENT.csv	OffGas
LVP	ChemAdd_LVP	56	AMR-VSL-00001-2-AIR_LVP-SCR-00001-2.csv	ChemAdd
LVP	ChemAdd_LVP	56	AMR-VSL-00001-2-NH3_LVP-SCR-00001-2.csv	ChemAdd
LVP	ChemAdd_LVP	56	LAW-VESSEL-VENT-AIR_LAW-VESSEL-VENT.csv	ChemAdd
LVP	LAWRLD_LVP	57	LVP-TK-00001_LVP-SCB-00001.csv	Waste
LVP	LAW-Stack	58	LVP-SCB-00001_LAW-STACK.csv	OffGas
LAW-RLD	LVP_LAWRLD	59	LVP-SCB-00001_LVP-TK-00001.csv	Waste
LAW-RLD	LOP_LAWRLD	60	LOP-SCB-00001_RLD-VSL-00005.csv	Waste
LAW-RLD	LOP_LAWRLD	60	LOP-SCB-00002_RLD-VSL-00005.csv	Waste
LAW-RLD	LOP_LAWRLD	60	LOP-WESP-00001_RLD-VSL-00004.csv	Waste
LAW-RLD	LOP_LAWRLD	60	LOP-WESP-00002_RLD-VSL-00004.csv	Waste
LAW-RLD	ChemAdd_LAWRLD	61	LVP-VSL-00001-NAOH_LVP-TK-00001.csv	ChemAdd
LAW-RLD	ChemAdd_LAWRLD	61	LVP-VSL-00001-WATER_LVP-TK-00001.csv	ChemAdd
HFP	HLP_HFP	62	HLP-VSL-00028_HFP-VSL-00001.csv	Waste
HFP	HLP_HFP	62	HLP-VSL-00028_HFP-VSL-00005.csv	Waste
HFP	ChemAdd_HFP	63	DIW-TK-00001_HFP-VSL-00001.csv	ChemAdd
HFP	ChemAdd_HFP	63	DIW-TK-00001_HFP-VSL-00002.csv	ChemAdd
HFP	ChemAdd_HFP	63	DIW-TK-00001_HFP-VSL-00005.csv	ChemAdd
HFP	ChemAdd_HFP	63	DIW-TK-00001_HFP-VSL-00006.csv	ChemAdd
HFP	ChemAdd_HFP	63	RHEOLOGY-HLW_HFP-VSL-00001.csv	ChemAdd
HFP	ChemAdd_HFP	63	RHEOLOGY-HLW_HFP-VSL-00005.csv	ChemAdd
HFP	GFormer_HFP	64	HFP-VSL-00001-MIXER_HFP-VSL-00001.csv	ChemAdd
HFP	GFormer_HFP	64	HFP-VSL-00005-MIXER_HFP-VSL-00005.csv	ChemAdd
HMP	HFP_HMP	65	HFP-VSL-00002_HMP-MLTR-00001.csv	Waste
HMP	HFP_HMP	65	HFP-VSL-00006_HMP-MLTR-00002.csv	Waste
HMP	ChemAdd_HMP	66	HMP-MLTR-00001-AIR_HMP-MLTR-	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
			00001.csv	
HMP	ChemAdd_HMP	66	HMP-MLTR-00002-AIR_HMP-MLTR-00002.csv	ChemAdd
HMP	HMP_IHLW	67	HMP-MLTR-00001_HLW-CANISTERS-1.csv	IHLW
HMP	HMP_IHLW	67	HMP-MLTR-00002_HLW-CANISTERS-2.csv	IHLW
HOP	HMP_HOP	68	HMP-MLTR-00001_HOP-SCB-00001.csv	Waste
HOP	HMP_HOP	68	HMP-MLTR-00002_HOP-SCB-00002.csv	Waste
HOP	ChemAdd_HOP	69	DIW-TK-00002_HOP-HEME-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	DIW-TK-00002_HOP-HEME-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	DIW-TK-00002_HOP-WESP-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	DIW-TK-00002_HOP-WESP-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	HLW-VESSEL-VENT-1-AIR_HLW-VESSEL-VENT-1.csv	ChemAdd
HOP	ChemAdd_HOP	69	HLW-VESSEL-VENT-2-AIR_HLW-VESSEL-VENT-2.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP08-1_HOP-SCB-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP08-2_HOP-SCB-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP-SCR-00001-AIR_HOP-SCR-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP-SCR-00001-NH3_HOP-SCR-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP-SCR-00002-AIR_HOP-SCR-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	HOP-SCR-00002-NH3_HOP-SCR-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	PSA_HOP-SCB-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	PSA_HOP-SCB-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	RFD-AIR_HOP-SCB-00001.csv	ChemAdd
HOP	ChemAdd_HOP	69	RFD-AIR_HOP-SCB-00002.csv	ChemAdd
HOP	ChemAdd_HOP	69	RLD-VSL-00007_PJV-HEPA-00004-5.csv	ChemAdd
HOP	HLW-Stacks	70	HOP-SCR-00001_HLW-STACK.csv	OffGas
HOP	HLW-Stacks	70	HOP-SCR-00002_HLW-STACK.csv	OffGas
HOP	HLW-Stacks	70	PJV-HEPA-00004-5_HLW-PJV-STACK.csv	OffGas
RLD-HLW	HOP_HLWRLD	71	HOP-SCB-00001_RLD-VSL-00007.csv	Waste
RLD-HLW	HOP_HLWRLD	71	HOP-SCB-00002_RLD-VSL-00007.csv	Waste
RLD-HLW	HDH_HLWRLD	72	HDH-VSL-00003_RLD-VSL-00007.csv	Waste
RLD-HLW	ChemAdd_HLWRLD	73	DIW-TK-00001_RLD-VSL-00007.csv	ChemAdd
RLD-HLW	ChemAdd_HLWRLD	73	HDH-VSL-00003-FLUSH_RLD-VSL-00007.csv	ChemAdd
RLD-HLW	ChemAdd_HLWRLD	73	PSA_RLD-VSL-00007.csv	ChemAdd
RLD-HLW	ChemAdd_HLWRLD	73	RFD-AIR_RLD-VSL-00007.csv	ChemAdd
RLD-HLW	ChemAdd_HLWRLD	73	SHR-TK-00002_RLD-VSL-00007.csv	ChemAdd
HDH	ChemAdd_HDH	74	DIW-TK-00001_HDH-VSL-00003.csv	ChemAdd
HDH	ChemAdd_HDH	74	DIW-TK-00002_HDH-VSL-00002.csv	ChemAdd
HDH	ChemAdd_HDH	74	DIW-TK-00002_HDH-VSL-00004.csv	ChemAdd
HDH	ChemAdd_HDH	74	HDH-TK-00002_HDH-VSL-00002.csv	ChemAdd
HDH	ChemAdd_HDH	74	HDH-TK-00002_HDH-VSL-00004.csv	ChemAdd
HDH	ChemAdd_HDH	74	HDH-TK-00003_HDH-VSL-00003.csv	ChemAdd
HDH	ChemAdd_HDH	74	HDH-VSL-00001-WATER_HDH-VSL-00001.csv	ChemAdd
HDH	ChemAdd_HDH	74	HPS_HDH-VSL-00003.csv	ChemAdd

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
HDH	ChemAdd_HDH	74	NAR-TK-00001_HDH-VSL-00002.csv	ChemAdd
HDH	ChemAdd_HDH	74	NAR-TK-00001_HDH-VSL-00004.csv	ChemAdd
HDH	ChemAdd_HDH	74	SHR-TK-00002_HDH-VSL-00003.csv	ChemAdd
PWD	HLWRLD_Recycle	75	RLD-VSL-00007_PWD-VSL-00043.csv	Waste
PWD	CNP_Recycle	76	CNP-EVAP-00001_PWD-VSL-00015.csv	Waste
PWD	CNP_Recycle	76	CNP-EVAP-00001_PWD-VSL-00016.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00001_PWD-VSL-00015.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00001_PWD-VSL-00016.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00002_PWD-VSL-00015.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00002_PWD-VSL-00016.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00003_PWD-VSL-00015.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00003_PWD-VSL-00016.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00004_PWD-VSL-00015.csv	Waste
PWD	CXP_Recycle	77	CXP-IXC-00004_PWD-VSL-00016.csv	Waste
PWD	CXP_Recycle	77	CXP-FILT-00001_PWD-VSL-00016.csv	Waste
HLP27A	FEP_HLP27A	78	FEP-SEP-00001A_HLP-VSL-00027A.csv	Waste
HLP27A	FEP_HLP27A	78	FEP-SEP-00001B_HLP-VSL-00027A.csv	Waste
FRP2A	FEP_FRP2A	79	FEP-SEP-00001A_FRP-VSL-00002A.csv	Waste
FRP2A	FEP_FRP2A	79	FEP-SEP-00001B_FRP-VSL-00002A.csv	Waste
UFP	HLP27A_UFP1	80	HLP-VSL-00027A_UFP-VSL-00001A.csv	Waste
UFP	HLP27A_UFP1	80	HLP-VSL-00027A_UFP-VSL-00001B.csv	Waste
PT-RLD	LineFlush	81	RLD-TK-00006A_CXP-VSL-00026A.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_CXP-VSL-00026B.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_CXP-VSL-00026C.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FEP-SEP-00001A.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FEP-SEP-00001B.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FEP-VSL-00017A.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FEP-VSL-00017B.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FRP-VSL-00002A.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FRP-VSL-00002B.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FRP-VSL-00002C.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_FRP-VSL-00002D.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_HLP-VSL-00022.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_RDP-VSL-00002B.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_SUPPLEMENTAL-LAW-RECYCLE.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_TCP-VSL-00001.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_TLP-SEP-00001.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_TLP-VSL-00009A.csv	ProCond
PT-RLD	LineFlush	81	RLD-TK-00006A_TLP-VSL-00009B.csv	ProCond
CXP	GuardFilter_Backflush	82	CXP-FILT-00001_PWD-VSL-00016.csv	Waste
LVP	LVP_Removed	83	LVP-ADBR-00001AB_LVP-ADBR-00001AB.csv	OffGas
LVP	LVP_Removed	83	LVP-HEPA-00001AB_LVP-HEPA-00001AB.csv	OffGas
LVP	LVP_Removed	83	LVP-SCR-00001-2_LVP-SCR-00001-2.csv	OffGas

System Name	Stream Name	Stream ID	Totalizer File Name	Waste Type
HOP	HOP_Removed	84	HOP-ABS-00002_HOP-ABS-00002.csv	OffGas
HOP	HOP_Removed	84	HOP-ABS-00003_HOP-ABS-00003.csv	OffGas
HOP	HOP_Removed	84	HOP-ADBR-00001AB_HOP-ADBR-00001AB.csv	OffGas
HOP	HOP_Removed	84	HOP-ADBR-00002AB_HOP-ADBR-00002AB.csv	OffGas
HOP	HOP_Removed	84	HOP-HEPA-00001-2-AB_HOP-HEPA-00001-2-AB.csv	OffGas
HOP	HOP_Removed	84	HOP-HEPA-00007-8-AB_HOP-HEPA-00007-8-AB.csv	OffGas
HOP	HOP_Removed	84	HOP-SCR-00001_HOP-SCR-00001.csv	OffGas
HOP	HOP_Removed	84	HOP-SCR-00002_HOP-SCR-00002.csv	OffGas
HOP	HOP_Removed	84	PJV-HEPA-00004-5_PJV-HEPA-00004-5.csv	OffGas
PVP	PVP_Removed	85	PJV-HEPA_PJV-HEPA.csv	OffGas
PVP	PVP_Removed	85	PVP-ABS-00001AB_PVP-ABS-00001AB.csv	OffGas
PVP	PVP_Removed	85	PVP-HEPA-00001-2_PVP-HEPA-00001-2.csv	OffGas
PVP	PVP_Removed	85	PVP-OXID-00001_PVP-OXID-00001.csv	OffGas
UFP	IXC_Displacement	86	CXP-IXC-00001_UFP-VSL-00062A.csv	Waste
UFP	IXC_Displacement	86	CXP-IXC-00002_UFP-VSL-00062A.csv	Waste
UFP	IXC_Displacement	86	CXP-IXC-00003_UFP-VSL-00062A.csv	Waste
UFP	IXC_Displacement	86	CXP-IXC-00004_UFP-VSL-00062A.csv	Waste
UFP	IXC_Displacement	86	IX-DI-WATER_UFP-VSL-00062A.csv	Waste

Table J-2 Visual C# Routine for Mass Balance Flowsheet Diagrams

```
using System;
using System.IO;
using System.Collections;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;
using Microsoft.Office.Interop.Excel;
using System.Threading;

namespace G2MBC_GUI
{
    public partial class G2MassBalanceCalculator : Form
    {
        ArrayList systemName = new ArrayList();
        ArrayList streamName = new ArrayList();
        ArrayList streamID = new ArrayList();
        ArrayList totalizerFile = new ArrayList();
        ArrayList classification = new ArrayList();

        int streamCount;
        double[] liqMassTotal, solMassTotal, gasMassTotal, oxMassTotal, massTotal;
        double[] liqVolTotal, solVolTotal, volTotal;
        double[,] liqMassComp, solMassComp, oxMassComp, gasMassComp;
        string[] lsCompName, oxCompName, gasCompName;

        string outputHeader;
        string sysName = "SystemName\t";
        string strName = "StreamName\t";
        string strID = "StreamID\t";
        string classi = "Classification\t";
        string oldName = "";
        string liqMassLine = "Liq. Mass (kgs)\t";
        string solMassLine = "Sol. Mass (kgs)\t";
        string gasMassLine = "Gas Mass (kgs)\t";
        string oxMassLine = "Ox. Mass (kgs)\t";
    }
}
```

```

string massTotalLine = "Total Mass (kgs)\t";
string liqVolLine = "Liq. Volume (gal)\t";
string solVolLine = "Sol. Volume (gal)\t";
string gasVolLine = "Gas Volume (cf)\t";
string oxVolLine = "Ox. Volume (gal)\t";
string volTotalLine = "Total Volume (gal)\t";
string disclaimer1 = "Mass in storage is not accounted for within each system, \t";
string disclaimer2 = "Round off could impact streams with small quantities. \t";
string disclaimer3 = "Volumes are not conserved due to mixing and reactions, \t";
string disclaimer4 = "volumes in the gaseous phase are not tracked. \t";
string disclaimer5 = "Large err% is caused by large heel to throughput volume ratio (e.g., in
    CRP/RDP and CNP) and/or by round off (e.g., trace quantities of Rads). \t";
string disclaimer6 = "Residual H+ and Na+ in disposed spent resin are ignored";
string disclaimer7 = "End of mission recycle is stored in FEP17A/B without processing";

enum gasIndex
{
    co2, h2o, hcl, hf, n2, nh3, no, no2, o2, p2o5, so2, il29, so3, c12h4cl6, c2h3n, hg
}

static double[] gasMW =
{
    44.01, 18.015, 36.461, 20.006, 28.013, 17.03, 30.006, 46.005, 31.999,
    141.945, 64.059, 128.905, 80.062, 360.852, 41.054, 200.59
};

enum oxIndex
{
    ac2o3, ag2o, al2o3, am2o3, as2o5, b2o3, bao, beo, bi2o3, cao, cdo, ce2o3,
    clOx, cm2o3, coo, cr2o3, cs2o, cuo, dy2o3, eu2o3, fOx, fe2o3, hgo, k2o,
    la2o3, li2o, mgo, mno, moo3, na2o, nb2o5, nd2o3, nio, npo2, p2o5, pbo,
    pdo, pr2o3, puo2, rb2o, re2o7, rh2o3, ruo2, sb2o3, seo2, sio2, sm2o3,
    sno2, so3, sro, ta2o5, tc2o7, teo2, tho2, tio2, tl2o, uo3, v2o5, wo3,
    y2o3, zno, zro2, co2Ox, h2obound, h2oOx, hfo2, mnp2o3, nap2o, il29Ox,
    pa2o3, rao, c12h22o11, ox5
}

static double[] oxideMW =
{

```

```

501.9982, 231.7354, 101.9612, 533.9982, 229.8402, 69.6182, 153.3394,
25.0116, 465.9598, 56.0794, 128.3994, 328.2382, 35.453, 541.9982,
74.9326, 151.9902, 289.9994, 79.5454, 372.9982, 351.9182,18.9984,
159.6922, 216.5894, 94.1794, 325.8092, 29.8794, 40.3044, 70.9374,
143.9382, 61.979, 265.8098, 336.4782, 74.7094, 269.047, 141.9446,
223.1994, 122.3994, 329.8136, 270.9988, 186.9334, 484.3958,253.8092,
133.0688, 291.4982, 110.9588, 60.0848, 348.7982, 150.6888,80.0582,
105.9994, 441.891, 309.8082, 159.5988, 264.0369, 79.8988, 424.7394,
286.0282, 181.879, 231.8482, 225.81, 81.3794, 123.2188,44.01,
18.015, 18.015, 210.489, 157.8745, 61.979, 128.905, 510.0,
242.0, 342.299, 0.0
};

enum lsIndex
{
    ru106, cd113, sb125, sn126, il29, cs134, cs137, ba137, c14, sm151, eu152,
    eu154, eu155, ra226, ac227, ra228, th229, pa231, th232, u232, u233, u234,
    u235, u236, np237, pu238, u238, pu239, pu240, am241, pu241, cm242, pu242,
    am243, cm243, cm244, h3, ni59, co60, ni63, se79, sr90, y90, zr93, nb93,
    tc99, ag, aloh4, al3, as5, b3, ba2, be2, bi3, c10h12n2o8, c10h15n2o7,
    c12h27o4p, c13h28, c2cl4, c2h3o2, c2h3o3, c2hcl3, c2o4, c3h6o, c4h10o,
    c4h8o, c5h5n, c6h5no2, c6h5o7, c6h6, c7h6n2o4, c7h8o, ca2, cd2, ce3,
    ch2cl2, chcl3, cho2, cl, cn, co3, co32, croh4, cr, cs, cu2, f, fe3, h,
    h2o, h2o2, hg2, k, la3, li, mg2, mn4, mno2, mno4, mo6, na, nd3, nh3, ni2,
    no2, no3, ohbound, oh, pb2, pd2, po43, pr3, pu4, rb, rh3, ru3, sb5, se6,
    si4, so42, sr2, ta5, tc7, te6, th4, ti4, tl3, toc, utotal, v5, w6, y3, zn2,
    zr4, c10h8, c12h4cl6, c12h8, c2h3n, c2h6sio, c2h8n2, h2obound, c4h7no4, c6h6o,
    c7h8, c8h8o, ccl4, h2co3, hco3, mnp, nap, nh4, o, aloh3, po43hard, ppg, dppg,
    pdms, dpdms, no3d, alooh, ls9, ls10
}

// kgs/mole
static double[] lsMW =
{
    105.9073, 112.9044, 124.9053, 125.9077, 128.905, 133.9067, 136.9071,
    136.9058, 14.003, 150.9199, 151.9217, 153.923, 154.9229, 226.0254,
    227.0278, 228.0311, 229.0318, 231.0359, 232.0381, 232.0372, 233.0396,
    234.041, 235.0439, 236.0456, 237.0482, 238.0496, 238.0508, 239.0522,
    240.0538, 241.0568, 241.0569, 242.0588, 242.0587, 243.0614, 243.0614,
    244.0628, 3.016, 58.9343, 59.9338, 62.9297, 78.9185, 89.9077, 89.9072,

```



```

92.9065, 92.9064, 98.9063, 107.868, 95.0107, 26.9815, 74.9216, 10.81,
137.34, 9.0122, 208.9808, 288.2134, 275.2377, 266.3167, 184.3642,
165.834, 59.0445, 75.0439, 131.3889, 88.0196, 58.0798, 74.1224, 72.1066,
79.1012, 123.111, 189.1013, 78.1134, 182.1354, 108.1396, 40.08, 112.4,
140.12, 84.9328, 119.3779, 45.0177, 35.453, 26.0177, 58.9332, 60.0092,
120.0252, 51.996, 137.63546, 18.9984, 55.847, 1.0079, 18.0152, 34.0146,
200.59, 39.09, 138.9055, 6.94, 24.305, 54.938, 86.9368, 118.9356, 95.94,
22.9898, 144.24, 17.0304, 58.71, 46.0055, 62.0049, 17.007, 17.0073,
207.2, 106.4, 94.9714, 140.9077, 239.85467, 102.9055, 101.07, 121.75,
78.96, 28.086, 96.0576, 90.0, 180.947, 98.9062, 127.6, 232.0381, 47.9,
204.37, 12.011, 238.029, 50.941, 183.85, 88.9059, 65.38, 91.22, 128.1753,
360.8837, 152.1976, 41.0529, 74.1555, 60.0995, 18.015, 133.1047, 94.1141,
92.1418, 120.1524, 153.8232, 62.0253, 61.0173, 54.938, 22.99, 18.0386,
15.9994, 78.0037, 94.9714, 3503.0, 3503.0, 35015.0, 35015.0, 62.0049, 59.988, 0.0, 0.0
};

// Ci/grams
static double[] lsSpActivity =
{
    3.3070E+03, 2.2440E+02, 1.0370E+03, 1.1350E-02, 1.7650E-04, 1.2920E+03,
    8.6780E+01, 5.3800E+08, 4.4680E+00, 2.6310E+01, 1.7370E+02, 2.7020E+02,
    4.8560E+02, 9.8930E-01, 7.2330E+01, 2.7220E+02, 2.1390E-01, 4.7180E-02,
    1.1000E-07, 2.2080E+01, 9.6380E-03, 6.2100E-03, 2.1600E-06, 6.4680E-05,
    7.0490E-04, 1.7130E+01, 3.3600E-07, 6.2070E-02, 2.2710E-01, 3.4280E+00,
    1.0300E+02, 3.3150E+03, 3.9390E-03, 1.9960E-01, 5.0560E+01, 8.0950E+01,
    9.6730E+03, 7.9730E-02, 1.1300E+03, 5.6750E+01, 6.9620E-03, 1.3800E+02,
    5.4340E+05, 2.5630E-03, 2.3880E+02, 1.6950E-02
};

string currentDir = Directory.GetCurrentDirectory();
Microsoft.Office.Interop.Excel.Application appObj;
Microsoft.Office.Interop.Excel._Workbook wbObj;
Microsoft.Office.Interop.Excel.Sheets wsObj;
Microsoft.Office.Interop.Excel._Worksheet sObj;
Microsoft.Office.Interop.Excel.Range rObj;

string xlTemplateFullName;
string xlCopyFullName;

public G2MassBalanceCalculator()

```

```

{
    InitializeComponent();
    mrqNum.Text = "11-0000";
    scenarioNum.Text = "7.0.1a";
    templatePicker.Text = "Unified Flowsheet";
    //flowsheetType.Text = "Cumulative Total Mass";
    two.Checked = true;
}

private void G2MassBalanceCalculator_Load(object sender, EventArgs e)
{
}

//Display instructions on message board
private void showInstructions(object sender, EventArgs e)
{
    string details;
    details = "This is how you shall run the program (to be added)";
    MessageBox.Show(details);
}

private void dateTimePicker1_ValueChanged(object sender, EventArgs e)
{
}

private void flowsheetType_SelectedIndexChanged(object sender, EventArgs e)
{
}

private void selectFolder1(object sender, EventArgs e)
{
    if (folderDialog1.ShowDialog() == DialogResult.OK)
    {
    }
}

private void selectFolder2(object sender, EventArgs e)
{
    if (one.Checked == true)
    {

```

```

        return;
    }

    if (folderDialog2.ShowDialog() == DialogResult.OK)
    {
    }
}

private void selectFolder3(object sender, EventArgs e)
{
    if (one.Checked == true || two.Checked == true)
    {
        return;
    }

    if (folderDialog3.ShowDialog() == DialogResult.OK)
    {
    }
}

//Open totalizer summary file
private void openFileDialogClick(object sender, EventArgs e)
{
    if (openSummaryFileDialog.ShowDialog() == DialogResult.OK)
    {
        StreamReader f = new StreamReader(openSummaryFileDialog.FileName);

        while (f.Peek() > -1)
        {
            string line = f.ReadLine();
            string[] tokens = line.Split(new char[] { ',' });
            if (tokens.Length == 5)
            {
                systemName.Add(tokens[0]);
                streamName.Add(tokens[1]);
                streamID.Add(tokens[2]);
                totalizerFile.Add(tokens[3]);
                classification.Add(tokens[4]);
            }
        }
    }
}

```

```

        f.Close();
    }
}

private void outputDialogClick(object sender, EventArgs e)
{
    if (outputFileDialog.ShowDialog() == DialogResult.OK)
    {
    }
}

//Confirm quitting G2MBC
private void closingCalculatorForm(object sender, FormClosingEventArgs e)
{
    DialogResult key = MessageBox.Show("Quit G2 Mass Balance Calculator", "Confirm",
    MessageBoxButtons.YesNo, MessageBoxIcon.
    Question);
    e.Cancel = (key == DialogResult.No);
}

private void closingCalculatorForm(object sender, System.EventArgs e)
{
    this.Close(); //button close
}

private void runCalculator(object sender, EventArgs e)
{
    calculateEntireFlowsheetMassBalance();

    if (templatePicker.Text != "Special Case, No Template")
    {
        foreach (string CheckedItems in flowsheetType.CheckedItems)
        {
            if (CheckedItems == "Cumulative Total Mass")
            {
                calculateCumulativeTotalMass();
            }
            else if (CheckedItems == "Cumulative Total Volume")
            {
                calculateCumulativeTotalVolume();
            }
        }
    }
}

```

```
}  
else if (CheckedItems == "Cumulative Radioactivity")  
{  
    calculateCumulativeRadioactivity();  
}  
else if (CheckedItems == "Aluminum")  
{  
    calculateAluminum();  
}  
else if (CheckedItems == "Chromium")  
{  
    calculateChromium();  
}  
else if (CheckedItems == "Iron")  
{  
    calculateIron();  
}  
else if (CheckedItems == "Sodium")  
{  
    calculateSodium();  
}  
else if (CheckedItems == "Oxalate")  
{  
    calculateOxalate();  
}  
else if (CheckedItems == "137-Cs")  
{  
    calculateCesium();  
}  
else if (CheckedItems == "90-Sr")  
{  
    calculateStrontium();  
}  
else if (CheckedItems == "129-I")  
{  
    calculateIodine();  
}  
else if (CheckedItems == "99-Tc")  
{  
    calculateTechnetium();  
}
```

```

    }
    else if (CheckedItems == "Mercury")
    {
        calculateMercury();
    }
    else if (CheckedItems == "Water")
    {
        calculateWater();
    }
    else if (CheckedItems == "AFA")
    {
        calculateAFA();
    }
    else if (CheckedItems == "Phosphate")
    {
        calculatePhosphate();
    }
}
MessageBox.Show("Flowsheet Mass Balance Calculation Completed!");
} //End flowsheetType

} //end runCalculator

private void calculateEntireFlowsheetMassBalance()
{
    int folderCount;
    string outputFilePath = outputFileDialog.SelectedPath;

    //determine totalizer file folders
    if (one.Checked == true)
    {
        folderCount = 1;
    }
    else if (two.Checked == true)
    {
        folderCount = 2;
    }
    else
    {
        folderCount = 3;
    }
}

```

```

}

//initialize calculation arrays
streamCount = int.Parse((string)(streamID[streamID.Count - 1]));
liqMassTotal = new double[streamCount];
solMassTotal = new double[streamCount];
gasMassTotal = new double[streamCount];
oxMassTotal = new double[streamCount];
massTotal = new double[streamCount];
liqVolTotal = new double[streamCount];
solVolTotal = new double[streamCount];
volTotal = new double[streamCount];
liqMassComp = new double[lsMW.Length, streamCount];
solMassComp = new double[lsMW.Length, streamCount];
oxMassComp = new double[oxideMW.Length, streamCount];
gasMassComp = new double[gasMW.Length, streamCount];
lsCompName = new string[lsMW.Length];
oxCompName = new string[oxideMW.Length];
gasCompName = new string[gasMW.Length];

//repeat calculation for totalizer file folders
for (int folder = 1; folder != folderCount + 1; folder++)
{
    string totalizerFilePath = ""; //initialize
    if (folder == 1)
    {
        totalizerFilePath = folderDialog1.SelectedPath + "\\ ";
    }
    else if (folder == 2)
    {
        totalizerFilePath = folderDialog2.SelectedPath + "\\ ";
    }
    else
    {
        totalizerFilePath = folderDialog3.SelectedPath + "\\ ";
    }

    //repeat every totalizer files/combine mass for same stream
    int fileCount = 0;
    int streamNum;

```

```

foreach (string currentFile in totalizerFile)
{
    //update progress status
    progressBar1.Maximum = totalizerFile.Count * folderCount;
    if (folder == 1)
    {
        progressBar1.Value = fileCount;
    }
    else if (folder == 2)
    {
        progressBar1.Value = totalizerFile.Count + fileCount;
    }
    else
    {
        progressBar1.Value = 2 * totalizerFile.Count + fileCount;
    }

    //calculate mass for one file
    streamNum = int.Parse((string)streamID[fileCount]) - 1;
    calculateOneFile(streamNum, totalizerFilePath, currentFile);
    fileCount++;
}

//calculate gas/oxide mass totals
for (int i = 0; i <= streamCount - 1; i++)
{
    double sum = 0;
    double sum1 = 0;

    for (int j = 0; j <= gasMW.Length - 1; j++)
    {
        sum += gasMassComp[j,i];
    }

    for (int j = 0; j <= oxideMW.Length - 1; j++)
    {
        sum1 += oxMassComp[j,i];
    }
}

```



```

        gasMassTotal[i] = sum;
        oxMassTotal[i] = sum1;
        //Solid mass does not includes oxide mass in G2,
        //but solid volume include oxide volume
        massTotal[i] = liqMassTotal[i] + solMassTotal[i] +
            gasMassTotal[i] + oxMassTotal[i];
        volTotal[i] = liqVolTotal[i] + solVolTotal[i];
    }

    for (int i = 0; i <= streamName.Count - 1; i++)
    {
        if ((string)streamName[i] != oldName)
        {
            sysName += (string)systemName[i] + "\t";
            strName += (string)streamName[i] + "\t";
            strID += (string)streamID[i] + "\t";
            classi += (string)classification[i] + "\t";
            oldName = (string)streamName[i];
        }
    }

    string analysisType = "Overall.xls";
    string flowsheetTitle = "WTP Flowsheet Data \r\n";
    outputHeader = "MRQ:\t" + mrqNum.Text + "\r\n" +
        "Scenario:\t" + scenarioNum.Text + "\r\n" +
        "Time:\t" + dateTimePicker1.Value + "\r\n" +
        sysName + "\r\n" +
        strName + "\r\n" +
        strID + "\r\n" +
        classi + "\r\n";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqMassLine += liqMassTotal[i].ToString() + "\t";
        solMassLine += solMassTotal[i].ToString() + "\t";
        gasMassLine += gasMassTotal[i].ToString() + "\t";
        oxMassLine += oxMassTotal[i].ToString() + "\t";
        massTotalLine += massTotal[i].ToString() + "\t";
        liqVolLine += liqVolTotal[i].ToString() + "\t";
        solVolLine += solVolTotal[i].ToString() + "\t";
    }

```

```

        gasVolLine += "n/a\t"; //gas vol is not tracked in G2
        oxVolLine += "n/a\t"; //ox. vol is part of sol. vol
        volTotalLine += volTotal[i].ToString() + "\t";
    }

    string textLine = liqMassLine + "\r\n" +
        solMassLine + "\r\n" +
        gasMassLine + "\r\n" +
        oxMassLine + "\r\n" +
        massTotalLine + "\r\n" +
        liqVolLine + "\r\n" +
        solVolLine + "\r\n" +
        gasVolLine + "\r\n" +
        oxVolLine + "\r\n" +
        volTotalLine + "\r\n";

    textLine = textLine + "Liquid Components (kgs)" + "\r\n";
    for (int j = 0; j <= lsMW.Length - 1; j++)
    {
        string liqMassCompLine = (string)lsCompName[j] + "\t";
        for (int i = 0; i <= streamCount - 1; i++)
        {
            liqMassCompLine += liqMassComp[j,i].ToString() + "\t";
        }
        textLine = textLine + liqMassCompLine + "\r\n";
    }

    textLine = textLine + "Solid Components (kgs)" + "\r\n";
    for (int j = 0; j <= lsMW.Length - 1; j++)
    {
        string solMassCompLine = (string)lsCompName[j] + "\t";
        for (int i = 0; i <= streamCount - 1; i++)
        {
            solMassCompLine += solMassComp[j, i].ToString() + "\t";
        }
        textLine = textLine + solMassCompLine + "\r\n";
    }

    textLine = textLine + "Oxide Components (kgs)" + "\r\n";
    for (int j = 0; j <= oxideMW.Length - 1; j++)

```

```

    {
        string oxMassCompLine = (string)oxCompName[j] + "\t";
        for (int i = 0; i <= streamCount - 1; i++)
        {
            oxMassCompLine += oxMassComp[j, i].ToString() + "\t";
        }
        textLine = textLine + oxMassCompLine + "\r\n";
    }

    textLine = textLine + "Gas Components (kgs)" + "\r\n";
    for (int j = 0; j <= gasMW.Length - 1; j++)
    {
        string gasMassCompLine = (string)gasCompName[j] + "\t";
        for (int i = 0; i <= streamCount - 1; i++)
        {
            gasMassCompLine += gasMassComp[j, i].ToString() + "\t";
        }
        textLine = textLine + gasMassCompLine + "\r\n";
    }

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
} //End of Entire Flowsheet

private void calculateOneFile(int streamNum, string totalizerFilePath, string currentFile)
{
    string oneLine;
    string[] tokens;
    StreamReader oneFile = new StreamReader(totalizerFilePath + currentFile);

    //skip lines 1 thru 2
    oneLine = oneFile.ReadLine();
    oneLine = oneFile.ReadLine();

    //repeat monthly data until EOF
    while (oneFile.Peek() > -1)
    {
        oneLine = oneFile.ReadLine();
        oneLine = oneFile.ReadLine();
        //read total mass
        oneLine = oneFile.ReadLine();
    }
}

```

```

tokens = oneLine.Split(new char[] { ',', ' ' });
if (tokens.Length == 3)
{
    liqMassTotal[streamNum] += double.Parse(tokens[1]);
    solMassTotal[streamNum] += double.Parse(tokens[2]);
}
//read total volume
oneLine = oneFile.ReadLine();
tokens = oneLine.Split(new char[] { ',', ' ' });
if (tokens.Length == 3)
{
    liqVolTotal[streamNum] += double.Parse(tokens[1]);
    solVolTotal[streamNum] += double.Parse(tokens[2]);
}

//skip 3lines
oneLine = oneFile.ReadLine();
oneLine = oneFile.ReadLine();
oneLine = oneFile.ReadLine();

//read liquid and solid
for (int i = 0; i <= lsMW.Length - 1; i++)
{
    oneLine = oneFile.ReadLine();
    tokens = oneLine.Split(new char[] { ',', ' ' });
    if (tokens.Length == 5)
    {
        lsCompName[i] = tokens[0];
        liqMassComp[i,streamNum] += double.Parse(tokens[1]);
        solMassComp[i,streamNum] += double.Parse(tokens[2]);
    }
}
} //end liquid and solid

//skip 3lines
oneLine = oneFile.ReadLine();
oneLine = oneFile.ReadLine();
oneLine = oneFile.ReadLine();

//read oxide
for (int i = 0; i <= oxideMW.Length - 1; i++)

```

```

    {
        oneLine = oneFile.ReadLine();
        tokens = oneLine.Split(new char[] { ',', ' ' });
        if (tokens.Length == 5)
        {
            oxCompName[i] = tokens[0];
            oxMassComp[i, streamNum] += double.Parse(tokens[4]);
        }
    } //end oxide

    //skip 3lines
    oneLine = oneFile.ReadLine();
    oneLine = oneFile.ReadLine();
    oneLine = oneFile.ReadLine();

    //read gas
    for (int i = 0; i <= gasMW.Length - 1; i++)
    {
        oneLine = oneFile.ReadLine();
        tokens = oneLine.Split(new char[] { ',', ' ' });
        if (tokens.Length == 5)
        {
            gasCompName[i] = tokens[0];
            gasMassComp[i, streamNum] += double.Parse(tokens[4]);
        }
    } //end gas

} //end repeat till EOF

oneFile.Close();
}

private void calculateCumulativeTotalMass()
{
    string analysisType = "CTM.xls";
    string flowsheetTitle = "Total Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqMassLine + "\r\n" +
        solMassLine + "\r\n" +
        gasMassLine + "\r\n" +
        oxMassLine + "\r\n" +

```

```

        massTotalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateCumulativeTotalVolume()
{
    string analysisType = "CTV.xls";
    string flowsheetTitle = "Total Volume Flowsheet Diagram (Unit = gal) \r\n";
    string textLine = liqVolLine + "\r\n" +
        solVolLine + "\r\n" +
        gasVolLine + "\r\n" +
        oxVolLine + "\r\n" +
        volTotalLine + "\r\n" +
        disclaimer3 + "\r\n" +
        disclaimer4 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateCumulativeRadioactivity()
{
    double[] liqRad = new double[streamCount];
    double[] solRad = new double[streamCount];
    double[] gasRad = new double[streamCount];
    double[] oxRad = new double[streamCount];
    double[] totalRad = new double[streamCount];
    string liqLine = "Liq. Activity (Ci)\t";
    string solLine = "Sol. Activity (Ci)\t";
    string gasLine = "Gas Activity (Ci)\t";
    string oxLine = "Ox. Activity (Ci)\t";
    string totalLine = "Total Activity (Ci)\t";

```

```

for (int i = 0; i <= streamCount - 1; i++)
{
    for (int j = 0; j <= lsSpActivity.Length - 1; j++)
    {
        liqRad[i] += liqMassComp[j, i] * 1000 * lsSpActivity[j];
        solRad[i] += solMassComp[j, i] * 1000 * lsSpActivity[j];
    }
    gasRad[i] += gasMassComp[(int)gasIndex.i129, i] * 1000 * lsSpActivity[(int)lsIndex.i129];
    oxRad[i] = 0.0; //oxRad only applies to melter output streams
    totalRad[i] = liqRad[i] + solRad[i] + gasRad[i] + oxRad[i];
}
oxRad[51] = totalRad[49] - totalRad[52]; //LAW melters (Stream 52 = Stream 50 - Stream 53)
totalRad[51] = oxRad[51];
oxRad[66] = totalRad[64] - totalRad[67]; //HLW melters (Stream 67 = Stream 65 - Stream 68)
totalRad[66] = oxRad[66];

for (int i = 0; i <= streamCount - 1; i++)
{
    liqLine += liqRad[i].ToString() + "\t";
    solLine += solRad[i].ToString() + "\t";
    gasLine += gasRad[i].ToString() + "\t";
    oxLine += oxRad[i].ToString() + "\t";
    totalLine += totalRad[i].ToString() + "\t";
}

string analysisType = "Rad.xls";
string flowsheetTitle = "Radioactivity Flowsheet Diagram (Unit = Ci) \r\n";
string textLine = liqLine + "\r\n" +
    solLine + "\r\n" +
    gasLine + "\r\n" +
    oxLine + "\r\n" +
    totalLine + "\r\n" +
    disclaimer1 + "\r\n" +
    disclaimer2 + "\r\n" +
    disclaimer5 + "\r\n" +
    disclaimer6 + "\r\n" +
    disclaimer7 + "\r\n";

clipboardPaste(textLine, analysisType, flowsheetTitle);

```

```

    }

    private void calculateAluminum()
    {
        double[] liqAl = new double[streamCount];
        double[] solAl = new double[streamCount];
        double[] oxAl = new double[streamCount];
        double[] totalAl = new double[streamCount];
        string liqLine = "Liq. Al (kgs)\t";
        string solLine = "Sol. Al (kgs)\t";
        string gasLine = "Gas Al (kgs)\t";
        string oxLine = "Ox. Al (kgs)\t";
        string totalLine = "Total Al (kgs)\t";

        for (int i = 0; i <= streamCount - 1; i++)
        {
            liqAl[i] = liqMassComp[(int)lsIndex.aloh4, i] * lsMW[(int)lsIndex.al3] /
                lsMW[(int)lsIndex.aloh4] + liqMassComp[(int)lsIndex.al3, i] +
                liqMassComp[(int)lsIndex.aloh3, i] *
                lsMW[(int)lsIndex.al3] / lsMW[(int)lsIndex.aloh3] + liqMassComp[(int)lsIndex.alooh, i] *
                lsMW[(int)lsIndex.al3] / lsMW[(int)lsIndex.alooh];
            solAl[i] = solMassComp[(int)lsIndex.aloh4, i] * lsMW[(int)lsIndex.al3] /
                lsMW[(int)lsIndex.aloh4] + solMassComp[(int)lsIndex.al3, i] +
                solMassComp[(int)lsIndex.aloh3, i] * lsMW[(int)lsIndex.al3] / lsMW[(int)lsIndex.aloh3] +
                solMassComp[(int)lsIndex.alooh, i] * lsMW[(int)lsIndex.al3] / lsMW[(int)lsIndex.alooh];
            oxAl[i] = 2 * oxMassComp[(int)oxIndex.al2o3, i] * lsMW[(int)lsIndex.al3] /
                oxideMW[(int)oxIndex.al2o3];
            totalAl[i] = liqAl[i] + solAl[i] + oxAl[i];
        }

        for (int i = 0; i <= streamCount - 1; i++)
        {
            liqLine += liqAl[i].ToString() + "\t";
            solLine += solAl[i].ToString() + "\t";
            gasLine += "n/a\t";
            oxLine += oxAl[i].ToString() + "\t";
            totalLine += totalAl[i].ToString() + "\t";
        }

        string analysisType = "Al.xls";
    }

```



```

string flowsheetTitle = "Aluminum Mass Flowsheet Diagram (Unit = kgs) \r\n";
string textLine = liqLine + "\r\n" +
                  solLine + "\r\n" +
                  gasLine + "\r\n" +
                  oxLine + "\r\n" +
                  totalLine + "\r\n" +
                  disclaimer1 + "\r\n" +
                  disclaimer2 + "\r\n" +
                  disclaimer5 + "\r\n" +
                  disclaimer6 + "\r\n" +
                  disclaimer7 + "\r\n";

        clipBoardPaste(textLine, analysisType, flowsheetTitle);
    }

private void calculateChromium()
{
    double[] liqCr = new double[streamCount];
    double[] solCr = new double[streamCount];
    double[] oxCr = new double[streamCount];
    double[] totalCr = new double[streamCount];
    string liqLine = "Liq. Cr (kgs)\t";
    string solLine = "Sol. Cr (kgs)\t";
    string gasLine = "Gas Cr (kgs)\t";
    string oxLine = "Ox. Cr (kgs)\t";
    string totalLine = "Total Cr (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqCr[i] = liqMassComp[(int)lsIndex.croh4, i] * lsMW[(int)lsIndex.cr] /
            lsMW[(int)lsIndex.croh4] + liqMassComp[(int)lsIndex.cr, i];
        solCr[i] = solMassComp[(int)lsIndex.croh4, i] * lsMW[(int)lsIndex.cr] /
            lsMW[(int)lsIndex.croh4] + solMassComp[(int)lsIndex.cr, i];
        oxCr[i] = 2 * oxMassComp[(int)oxIndex.cr2o3, i] * lsMW[(int)lsIndex.cr] /
            oxideMW[(int)oxIndex.cr2o3];
        totalCr[i] = liqCr[i] + solCr[i] + oxCr[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {

```

```

        liqLine += liqCr[i].ToString() + "\t";
        solLine += solCr[i].ToString() + "\t";
        gasLine += "n/a\t";
        oxLine += oxCr[i].ToString() + "\t";
        totalLine += totalCr[i].ToString() + "\t";
    }

    string analysisType = "Cr.xls";
    string flowsheetTitle = "Chromium Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateIron()
{
    double[] liqFe = new double[streamCount];
    double[] solFe = new double[streamCount];
    double[] oxFe = new double[streamCount];
    double[] totalFe = new double[streamCount];
    string liqLine = "Liq. Fe (kgs)\t";
    string solLine = "Sol. Fe (kgs)\t";
    string gasLine = "Gas Fe (kgs)\t";
    string oxLine = "Ox. Fe (kgs)\t";
    string totalLine = "Total Fe (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqFe[i] = liqMassComp[(int)lsIndex.fe3, i];
        solFe[i] = solMassComp[(int)lsIndex.fe3, i];
        oxFe[i] = 2 * oxMassComp[(int)oxIndex.fe2o3, i] * lsMW[(int)lsIndex.fe3] /

```

```

        oxideMW[(int)oxIndex.fe2o3];
        totalFe[i] = liqFe[i] + solFe[i] + oxFe[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqLine += liqFe[i].ToString() + "\t";
        solLine += solFe[i].ToString() + "\t";
        gasLine += "n/a\t";
        oxLine += oxFe[i].ToString() + "\t";
        totalLine += totalFe[i].ToString() + "\t";
    }

    string analysisType = "Fe.xls";
    string flowsheetTitle = "Iron Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateSodium()
{
    double[] liqNa = new double[streamCount];
    double[] solNa = new double[streamCount];
    double[] oxNa = new double[streamCount];
    double[] totalNa = new double[streamCount];
    string liqLine = "Liq. Na (kgs)\t";
    string solLine = "Sol. Na (kgs)\t";
    string gasLine = "Gas Na (kgs)\t";
    string oxLine = "Ox. Na (kgs)\t";
    string totalLine = "Total Na (kgs)\t";

```

```

for (int i = 0; i <= streamCount - 1; i++)
{
    liqNa[i] = liqMassComp[(int)lsIndex.na, i] + liqMassComp[(int)lsIndex.nap, i];
    solNa[i] = solMassComp[(int)lsIndex.na, i] + solMassComp[(int)lsIndex.nap, i];
    oxNa[i] = 2 * (oxMassComp[(int)oxIndex.na2o, i] + oxMassComp[(int)oxIndex.nap2o, i]) *
        lsMW[(int)lsIndex.na] / oxideMW[(int)oxIndex.na2o];
    totalNa[i] = liqNa[i] + solNa[i] + oxNa[i];
}

for (int i = 0; i <= streamCount - 1; i++)
{
    liqLine += liqNa[i].ToString() + "\t";
    solLine += solNa[i].ToString() + "\t";
    gasLine += "n/a\t";
    oxLine += oxNa[i].ToString() + "\t";
    totalLine += totalNa[i].ToString() + "\t";
}

string analysisType = "Na.xls";
string flowsheetTitle = "Sodium Mass Flowsheet Diagram (Unit = kgs) \r\n";
string textLine = liqLine + "\r\n" +
    solLine + "\r\n" +
    gasLine + "\r\n" +
    oxLine + "\r\n" +
    totalLine + "\r\n" +
    disclaimer1 + "\r\n" +
    disclaimer2 + "\r\n" +
    disclaimer5 + "\r\n" +
    disclaimer6 + "\r\n" +
    disclaimer7 + "\r\n";

clipboardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateOxalate()
{
    double[] liqC2O4 = new double[streamCount];
    double[] solC2O4 = new double[streamCount];
    double[] totalC2O4 = new double[streamCount];

```

```

string liqLine = "Liq. C204-2 (kgs)\t";
string solLine = "Sol. C204-2 (kgs)\t";
string gasLine = "Gas C204-2 (kgs)\t";
string oxLine = "Ox. C204-2 (kgs)\t";
string totalLine = "Total C204-2 (kgs)\t";

for (int i = 0; i <= streamCount - 1; i++)
{
    liqC204[i] = liqMassComp[(int)lsIndex.c2o4, i];
    solC204[i] = solMassComp[(int)lsIndex.c2o4, i];
    totalC204[i] = liqC204[i] + solC204[i];
}

for (int i = 0; i <= streamCount - 1; i++)
{
    liqLine += liqC204[i].ToString() + "\t";
    solLine += solC204[i].ToString() + "\t";
    gasLine += "n/a\t";
    oxLine += "n/a\t";
    totalLine += totalC204[i].ToString() + "\t";
}

string analysisType = "C204.xls";
string flowsheetTitle = "Oxalate Mass Flowsheet Diagram (Unit = kgs) \r\n";
string textLine = liqLine + "\r\n" +
    solLine + "\r\n" +
    gasLine + "\r\n" +
    oxLine + "\r\n" +
    totalLine + "\r\n" +
    disclaimer1 + "\r\n" +
    disclaimer2 + "\r\n" +
    disclaimer5 + "\r\n" +
    disclaimer6 + "\r\n" +
    disclaimer7 + "\r\n";

clipboardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateCesium()
{

```

```

double[] liqCs137 = new double[streamCount];
double[] solCs137 = new double[streamCount];
double[] oxCs137 = new double[streamCount];
double[] totalCs137 = new double[streamCount];
string liqLine = "Liq. Cs137 (kgs)\t";
string solLine = "Sol. Cs137 (kgs)\t";
string gasLine = "Gas Cs137 (kgs)\t";
string oxLine = "Ox. Cs137 (kgs)\t";
string totalLine = "Total Cs137 (kgs)\t";

for (int i = 0; i <= streamCount - 1; i++)
{
    liqCs137[i] = liqMassComp[(int)lsIndex.cs137, i];
    solCs137[i] = solMassComp[(int)lsIndex.cs137, i];
    //include non-radioactive Cs for now
    oxCs137[i] = 2 * oxMassComp[(int)oxIndex.cs2o, i] * lsMW[(int)lsIndex.cs] /
        oxideMW[(int)oxIndex.cs2o];
    totalCs137[i] = liqCs137[i] + solCs137[i] + oxCs137[i];
}

//overwrite Stream 52 (ILAW) and Stream 67 (IHLW) for non-radioactive Cs
totalCs137[52 - 1] = totalCs137[50 - 1] + totalCs137[51 - 1] - totalCs137[53 - 1];
oxCs137[52 - 1] = totalCs137[52 - 1];
totalCs137[67 - 1] = totalCs137[65 - 1] + totalCs137[66 - 1] - totalCs137[68 - 1];
oxCs137[67 - 1] = totalCs137[67 - 1];

for (int i = 0; i <= streamCount - 1; i++)
{
    liqLine += liqCs137[i].ToString() + "\t";
    solLine += solCs137[i].ToString() + "\t";
    gasLine += "n/a\t";
    oxLine += oxCs137[i].ToString() + "\t";
    totalLine += totalCs137[i].ToString() + "\t";
}

string analysisType = "Cs137.xls";
string flowsheetTitle = "Cesium 137 Mass Flowsheet Diagram (Unit = kgs) \r\n";
string textLine = liqLine + "\r\n" +
    solLine + "\r\n" +
    gasLine + "\r\n" +

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        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateStrontium()
{
    double[] liqSr90 = new double[streamCount];
    double[] solSr90 = new double[streamCount];
    double[] oxSr90 = new double[streamCount];
    double[] totalSr90 = new double[streamCount];
    string liqLine = "Liq. Sr90 (kgs)\t";
    string solLine = "Sol. Sr90 (kgs)\t";
    string gasLine = "Gas Sr90 (kgs)\t";
    string oxLine = "Ox. Sr90 (kgs)\t";
    string totalLine = "Total Sr90 (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqSr90[i] = liqMassComp[(int)lsIndex.sr90, i];
        solSr90[i] = solMassComp[(int)lsIndex.sr90, i];
        //include non-radioactive Sr for now
        oxSr90[i] = oxMassComp[(int)oxIndex.sro, i] * lsMW[(int)lsIndex.sr2] /
            oxideMW[(int)oxIndex.sro];
        totalSr90[i] = liqSr90[i] + solSr90[i] + oxSr90[i];
    }

    //overwrite Stream 52 (ILAW) and Stream 67 (IHLW) for non-radioactive Sr
    totalSr90[52 - 1] = totalSr90[50 - 1] + totalSr90[51 - 1] - totalSr90[53 - 1];
    oxSr90[52 - 1] = totalSr90[52 - 1];
    totalSr90[67 - 1] = totalSr90[65 - 1] + totalSr90[66 - 1] - totalSr90[68 - 1];
    oxSr90[67 - 1] = totalSr90[67 - 1];

    for (int i = 0; i <= streamCount - 1; i++)

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```

    {
        liqLine += liqSr90[i].ToString() + "\t";
        solLine += solSr90[i].ToString() + "\t";
        gasLine += "n/a\t";
        oxLine += oxSr90[i].ToString() + "\t";
        totalLine += totalSr90[i].ToString() + "\t";
    }

    string analysisType = "Sr90.xls";
    string flowsheetTitle = "Strontium 90 Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateIodine()
{
    double[] liqI129 = new double[streamCount];
    double[] solI129 = new double[streamCount];
    double[] gasI129 = new double[streamCount];
    double[] oxI129 = new double[streamCount];
    double[] totalI129 = new double[streamCount];
    string liqLine = "Liq. I129 (kgs)\t";
    string solLine = "Sol. I129 (kgs)\t";
    string gasLine = "Gas I129 (kgs)\t";
    string oxLine = "Ox. I129 (kgs)\t";
    string totalLine = "Total I129 (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqI129[i] = liqMassComp[(int)lsIndex.i129, i];
    }
}

```



```

        solI129[i] = solMassComp[(int)lsIndex.i129, i];
        gasI129[i] = gasMassComp[(int)gasIndex.i129, i];
        oxI129[i] = oxMassComp[(int)oxIndex.i129Ox, i];
        totalI129[i] = liqI129[i] + solI129[i] + gasI129[i] + oxI129[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqLine += liqI129[i].ToString() + "\t";
        solLine += solI129[i].ToString() + "\t";
        gasLine += gasI129[i].ToString() + "\t";
        oxLine += oxI129[i].ToString() + "\t";
        totalLine += totalI129[i].ToString() + "\t";
    }

    string analysisType = "I129.xls";
    string flowsheetTitle = "Iodine Mass Flowsheet Diagram (Unit = kgs)\r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculateTechnetium()
{
    double[] liqTc99 = new double[streamCount];
    double[] solTc99 = new double[streamCount];
    double[] oxTc99 = new double[streamCount];
    double[] totalTc99 = new double[streamCount];
    string liqLine = "Liq. Tc99 (kgs)\t";
    string solLine = "Sol. Tc99 (kgs)\t";
    string gasLine = "Gas Tc99 (kgs)\t";

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```

string oxLine = "Ox. Tc99 (kgs)\t";
string totalLine = "Total Tc99 (kgs)\t";

for (int i = 0; i <= streamCount - 1; i++)
{
    liqTc99[i] = liqMassComp[(int)lsIndex.tc99, i];
    solTc99[i] = solMassComp[(int)lsIndex.tc99, i];
    //include non-radioactive Tc
    oxTc99[i] = 2 * oxMassComp[(int)oxIndex.tc2o7, i] * lsMW[(int)lsIndex.tc7] /
        oxideMW[(int)oxIndex.tc2o7];
    totalTc99[i] = liqTc99[i] + solTc99[i] + oxTc99[i];
}

//overwrite Stream 52 (ILAW) and Stream 67 (IHLW) for non-radioactive Sr
totalTc99[52 - 1] = totalTc99[50 - 1] + totalTc99[51 - 1] - totalTc99[53 - 1];
oxTc99[52 - 1] = totalTc99[52 - 1];
totalTc99[67 - 1] = totalTc99[65 - 1] + totalTc99[66 - 1] - totalTc99[68 - 1];
oxTc99[67 - 1] = totalTc99[67 - 1];

for (int i = 0; i <= streamCount - 1; i++)
{
    liqLine += liqTc99[i].ToString() + "\t";
    solLine += solTc99[i].ToString() + "\t";
    gasLine += "n/a\t";
    oxLine += oxTc99[i].ToString() + "\t";
    totalLine += totalTc99[i].ToString() + "\t";
}

string analysisType = "Tc99.xls";
string flowsheetTitle = "Technetium 99 Mass Flowsheet Diagram (Unit = kgs)\r\n";
string textLine = liqLine + "\r\n" +
    solLine + "\r\n" +
    gasLine + "\r\n" +
    oxLine + "\r\n" +
    totalLine + "\r\n" +
    disclaimer1 + "\r\n" +
    disclaimer2 + "\r\n" +
    disclaimer5 + "\r\n" +
    disclaimer6 + "\r\n" +
    disclaimer7 + "\r\n";

```

```

        clipBoardPaste(textLine, analysisType, flowsheetTitle);
    }

private void calculateMercury()
{
    double[] liqHg = new double[streamCount];
    double[] solHg = new double[streamCount];
    double[] gasHg = new double[streamCount];
    double[] oxHg = new double[streamCount];
    double[] totalHg = new double[streamCount];
    string liqLine = "Liq. Hg (kgs)\t";
    string solLine = "Sol. Hg (kgs)\t";
    string gasLine = "Gas Hg (kgs)\t";
    string oxLine = "Ox. Hg (kgs)\t";
    string totalLine = "Total Hg (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqHg[i] = liqMassComp[(int)lsIndex.hg2, i];
        solHg[i] = solMassComp[(int)lsIndex.hg2, i];
        gasHg[i] = gasMassComp[(int)gasIndex.hg, i];
        oxHg[i] = oxMassComp[(int)oxIndex.hgo, i] * lsMW[(int)lsIndex.hg2] /
            oxideMW[(int)oxIndex.hgo];
        totalHg[i] = liqHg[i] + solHg[i] + gasHg[i] + oxHg[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqLine += liqHg[i].ToString() + "\t";
        solLine += solHg[i].ToString() + "\t";
        gasLine += gasHg[i].ToString() + "\t";
        oxLine += oxHg[i].ToString() + "\t";
        totalLine += totalHg[i].ToString() + "\t";
    }

    string analysisType = "Hg.xls";
    string flowsheetTitle = "Mercury Mass Flowsheet Diagram (Unit = kgs)\r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +

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        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}
private void calculateWater()
{
    double[] liqH2O = new double[streamCount];
    double[] solH2O = new double[streamCount];
    double[] gasH2O = new double[streamCount];
    double[] oxH2O = new double[streamCount];
    double[] totalH2O = new double[streamCount];
    string liqLine = "Liq. H2O (kgs)\t";
    string solLine = "Sol. H2O (kgs)\t";
    string gasLine = "Gas H2O (kgs)\t";
    string oxLine = "Ox. H2O (kgs)\t";
    string totalLine = "Total H2O (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqH2O[i] = liqMassComp[(int)lsIndex.h2o, i] + liqMassComp[(int)lsIndex.h2obound, i];
        solH2O[i] = solMassComp[(int)lsIndex.h2o, i] + solMassComp[(int)lsIndex.h2obound, i];
        gasH2O[i] = gasMassComp[(int)gasIndex.h2o, i];
        oxH2O[i] = oxMassComp[(int)oxIndex.h2oOx, i] + oxMassComp[(int)oxIndex.h2obound, i];
        totalH2O[i] = liqH2O[i] + solH2O[i] + gasH2O[i] + oxH2O[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqLine += liqH2O[i].ToString() + "\t";
        solLine += solH2O[i].ToString() + "\t";
        gasLine += gasH2O[i].ToString() + "\t";
        oxLine += oxH2O[i].ToString() + "\t";
        totalLine += totalH2O[i].ToString() + "\t";
    }
}

```

```

    }

    string analysisType = "H2O.xls";
    string flowsheetTitle = "Water Mass Flowsheet Diagram (Unit = kgs)\r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}
private void calculateAFA()
{
    double[] liqAFA = new double[streamCount];
    double[] solAFA = new double[streamCount];
    double[] oxAFA = new double[streamCount];
    double[] totalAFA = new double[streamCount];
    string liqLine = "Liq. AFA (kgs)\t";
    string solLine = "Sol. AFA (kgs)\t";
    string gasLine = "Gas AFA (kgs)\t";
    string oxLine = "Ox. AFA (kgs)\t";
    string totalLine = "Total AFA (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqAFA[i] = liqMassComp[(int)lsIndex.ppg, i] + liqMassComp[(int)lsIndex.dppg, i] +
            liqMassComp[(int)lsIndex.pdms, i] + liqMassComp[(int)lsIndex.dpdms, i];
        solAFA[i] = solMassComp[(int)lsIndex.ppg, i] + solMassComp[(int)lsIndex.dppg, i] +
            solMassComp[(int)lsIndex.pdms, i] + solMassComp[(int)lsIndex.dpdms, i];
        totalAFA[i] = liqAFA[i] + solAFA[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {

```

```

        liqLine += liqAFA[i].ToString() + "\t";
        solLine += solAFA[i].ToString() + "\t";
        gasLine += "n/a\t";
        oxLine += "n/a\t";
        totalLine += totalAFA[i].ToString() + "\t";
    }

    string analysisType = "AFA.xls";
    string flowsheetTitle = "Antifoam Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void calculatePhosphate()
{
    double[] liqPO43 = new double[streamCount];
    double[] solPO43 = new double[streamCount];
    double[] oxPO43 = new double[streamCount];
    double[] totalPO43 = new double[streamCount];
    string liqLine = "Liq. PO4-3 (kgs)\t";
    string solLine = "Sol. PO4-3 (kgs)\t";
    string gasLine = "Gas PO4-3 (kgs)\t";
    string oxLine = "Ox. PO4-3 equiv. (kgs)\t";
    string totalLine = "Total PO4-3 (kgs)\t";

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqPO43[i] = liqMassComp[(int)lsIndex.po43, i] + liqMassComp[(int)lsIndex.po43hard, i];
        solPO43[i] = solMassComp[(int)lsIndex.po43, i] + solMassComp[(int)lsIndex.po43hard, i];
        //P205 equivalent of PO4-3
    }
}

```

```

        oxPO43[i] = 2 * oxMassComp[(int)oxIndex.p2o5, i] * lsMW[(int)lsIndex.po43] /
            oxideMW[(int)oxIndex.p2o5];
        totalPO43[i] = liqPO43[i] + solPO43[i] + oxPO43[i];
    }

    for (int i = 0; i <= streamCount - 1; i++)
    {
        liqLine += liqPO43[i].ToString() + "\t";
        solLine += solPO43[i].ToString() + "\t";
        gasLine += "n/a\t";
        oxLine += oxPO43[i].ToString() + "\t";
        totalLine += totalPO43[i].ToString() + "\t";
    }

    string analysisType = "PO4-3.xls";
    string flowsheetTitle = "Phosphate Mass Flowsheet Diagram (Unit = kgs) \r\n";
    string textLine = liqLine + "\r\n" +
        solLine + "\r\n" +
        gasLine + "\r\n" +
        oxLine + "\r\n" +
        totalLine + "\r\n" +
        disclaimer1 + "\r\n" +
        disclaimer2 + "\r\n" +
        disclaimer5 + "\r\n" +
        disclaimer6 + "\r\n" +
        disclaimer7 + "\r\n";

    clipBoardPaste(textLine, analysisType, flowsheetTitle);
}

private void clipBoardPaste(string textLine, string analysisType, string flowsheetTitle)
{
    string outputFilePath = outputFileDialog.SelectedPath;
    string textMessages = flowsheetTitle + outputHeader + textLine;

    if (analysisType == "Overall.xls")
    {
        xlTemplateFullName = currentDir + "\\Overall_Template.xls";
    }
    else

```

```

{
    if (templatePicker.Text == "Unified Flowsheet")
    {
        xlTemplateFullName = currentDir + "\\Unified_Template.xls";
    }
    if (templatePicker.Text == "Leaching in UFP2")
    {
        xlTemplateFullName = currentDir + "\\UFP2_Template.xls";
    }
    else if (templatePicker.Text == "Leaching in UFP1")
    {
        xlTemplateFullName = currentDir + "\\UFP1_Template.xls";
    }
    else if (templatePicker.Text == "Leaching in UFP1 w/ HLP Reconfigured")
    {
        //to be developed
        xlTemplateFullName = currentDir + "\\UFP1_HLP_Template.xls";
    }
}

xlCopyFullName = outputFilePath + "\\mrq_" + mrqNum.Text + "_scenario_" + scenarioNum.Text +
    "_" + analysisType;
showProgress(xlCopyFullName);
File.Copy(xlTemplateFullName, xlCopyFullName);

Clipboard.SetDataObject(textMessages);
appObj = new Microsoft.Office.Interop.Excel.Application();
wbObj = appObj.Workbooks.Open(xlCopyFullName, Type.Missing, Type.Missing,
    Type.Missing, Type.Missing, Type.Missing, Type.Missing, Type.Missing,
    Type.Missing, Type.Missing, Type.Missing, Type.Missing, Type.Missing,
    Type.Missing, Type.Missing);
wsObj = wbObj.Sheets;
sObj = (Microsoft.Office.Interop.Excel.Worksheet)wsObj.get_Item("Data");

string pasteRange = determinePasteRange();
if (pasteRange == "Your stream no. is longer than what Excel can handle")
{
    MessageBox.Show(pasteRange);
}

```



```

if (analysisType == "Overall.xls")
{
    rObj = sObj.get_Range("A1", pasteRange + "435");
}
else
{
    rObj = sObj.get_Range("A1", pasteRange + "18");
}

sObj.Paste(rObj, false);
wbObj.Save();
wbObj.Close(false, Type.Missing, Type.Missing);
appObj.Quit();
}

private string determinePasteRange()
{
    string[] alphbets = {"A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M",
                        "N", "O", "P", "Q", "R", "S", "T", "U", "V", "W", "X", "Y", "Z"};

    if (1 + streamCount <= alphbets.Length)
        return alphbets[streamCount];
    else if (1 + streamCount <= 2 * alphbets.Length)
        return "A" + alphbets[streamCount - alphbets.Length];
    else if (1 + streamCount <= 3 * alphbets.Length)
        return "B" + alphbets[streamCount - 2 * alphbets.Length];
    else if (1 + streamCount <= 4 * alphbets.Length)
        return "C" + alphbets[streamCount - 3 * alphbets.Length];
    else if (1 + streamCount <= 5 * alphbets.Length)
        return "D" + alphbets[streamCount - 4 * alphbets.Length];
    else if (1 + streamCount <= 6 * alphbets.Length)
        return "E" + alphbets[streamCount - 5 * alphbets.Length];
    else if (1 + streamCount <= 7 * alphbets.Length)
        return "F" + alphbets[streamCount - 6 * alphbets.Length];
    else if (1 + streamCount <= 8 * alphbets.Length)
        return "G" + alphbets[streamCount - 7 * alphbets.Length];
    else if (1 + streamCount <= 9 * alphbets.Length)
        return "H" + alphbets[streamCount - 8 * alphbets.Length];
    else
        return "Your stream no. is longer than what Excel can handle";
}

```

```
    }  
  
    private void showProgress(string fileCreationMessage)  
    {  
        MessageBox.Show("Writing to " + fileCreationMessage, "Click OK to continue");  
    }  
  
} //end Form  
}
```

Table J-3 Volume Throughput Data for RLD-VSL-0006A by TVExtractor

Upstream	Downstream	Output Time	30-May-18	29-Jun-18	29-Jul-18	28-Aug-18	27-Sep-18	27-Oct-18	26-Nov-18	26-Dec-18
RLD6A	FRP2A	(gal)	490	977	871	853	700	758	868	741
RLD6A	FRP2B	(gal)	2,309	1,721	546	521	2,332	3,631	1,207	1,667
RLD6A	FRP2C	(gal)	963	1,771	3,166	4,049	2,566	1,404	2,946	3,996
RLD6A	FRP2D	(gal)	276	276	138	437	415	276	276	437
RLD6A	HLP22	(gal)	0	0	0	290	97	0	68	386
RLD6A	FEP17A	(gal)	5,933	7,038	7,423	7,613	8,214	9,081	8,128	8,825
RLD6A	FEP17B	(gal)	418	756	645	489	655	604	655	453
RLD6A	FEP-EVAP	(gal)	277	553	632	395	434	395	474	356
RLD6A	UFP1A	(gal)	4,179	4,252	4,833	4,886	5,658	6,808	5,097	5,658
RLD6A	UFP1B	(gal)	4,274	4,129	4,274	5,181	5,115	6,233	4,970	6,167
RLD6A	UFP2A	(gal)	140,468	206,172	203,466	161,067	203,087	172,480	220,407	209,067
RLD6A	UFP2B	(gal)	174,820	105,139	194	97	97	194	80,134	81,433
RLD6A	SUPERTANK	(gal)	0	0	0	0	0	32,700	73,800	77,750
RLD6A	RDP2B	(gal)	0	0	0	0	0	0	0	0
RLD6A	TLP9A	(gal)	1,153	1,998	1,923	1,826	1,947	1,281	1,315	1,187
RLD6A	TLP9B	(gal)	1,257	1,973	1,973	1,863	1,915	1,315	1,264	1,206
RLD6A	CXP26A	(gal)	591	591	739	739	739	887	813	961
RLD6A	CXP26B	(gal)	677	762	847	847	931	1,016	931	931
RLD6A	CXP26C	(gal)	521	587	587	717	652	847	782	782
RLD6A	TLP-EVAP	(gal)	369	415	446	476	492	569	553	553
RLD6A	TCP1	(gal)	4,299	5,904	6,281	6,017	6,185	5,326	4,959	4,979
RLD6A	HLP27A	(gal)	94	0	94	94	94	0	94	0
RLD6A	HLP27B	(gal)	336	336	427	0	245	182	0	336
RLD6A	HLP28	(gal)	2,084	4,458	4,442	2,244	2,104	3,178	4,063	2,639
RLD6A	PWD33	(gal)	31	31	61	0	0	61	0	31
RLD6A	PWD43	(gal)	476	2,501	2,382	1,072	1,667	1,667	1,905	1,429

Table J-4 Visual C# Routine for Totalizer Value Extractor

```

using System;
using System.IO;
using System.Collections;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Text;
using System.Windows.Forms;
using Microsoft.Office.Interop.Excel;
using System.Threading;

namespace G2MBC_GUI
{
    public partial class TVExtractor : Form
    {
        ArrayList upstreamName = new ArrayList();
        ArrayList downstreamName = new ArrayList();
        ArrayList streamID = new ArrayList();
        ArrayList totalizerFile = new ArrayList();

        int rowCount;
        int columnCount;

        double liqVolTotal, solVolTotal;
        double[,] volTotal;
        string[] timeStamp;

        string upstrmName = "Upstream \t";
        string downstrmName = "Downstream \t";
        string unitLine = "Output Time \t";
        string oneLine;
        string outputFilePath;

        StreamWriter textOut;

        //constructor
        public TVExtractor()

```

```

{
    InitializeComponent();
    mrqNum.Text = "11-0000";
    scenarioNum.Text = "7.0.1a";
    systemName.Text = "FEP";
    two.Checked = true;
}

private void TVExtractorr_Load(object sender, EventArgs e)
{
}

//Display instructions on message board
private void showInstructions(object sender, EventArgs e)
{
    string details;
    details = "This is how you shall run the program (to be added)";
    MessageBox.Show(details);
}

private void dateTimePicker1_ValueChanged(object sender, EventArgs e)
{
}

private void selectFolder1(object sender, EventArgs e)
{
    if (folderDialog1.ShowDialog() == DialogResult.OK)
    {
    }
}

private void selectFolder2(object sender, EventArgs e)
{
    if (one.Checked == true)
    {
        return;
    }

    if (folderDialog2.ShowDialog() == DialogResult.OK)
    {
    }
}

```

```

    }
}

private void selectFolder3(object sender, EventArgs e)
{
    if (one.Checked == true || two.Checked == true)
    {
        return;
    }

    if (folderDialog3.ShowDialog() == DialogResult.OK)
    {
    }
}

//Open totalizer summary file
private void openFileDialogClick(object sender, EventArgs e)
{
    if (openSummaryFileDialog.ShowDialog() == DialogResult.OK)
    {
        StreamReader textIn = new StreamReader(openSummaryFileDialog.FileName);

        while (textIn.Peek() > -1)
        {
            string line = textIn.ReadLine();
            string[] tokens = line.Split(new char[] { ',' });
            if (tokens.Length == 4)
            {
                upstreamName.Add(tokens[0]);
                downstreamName.Add(tokens[1]);
                streamID.Add(tokens[2]);
                totalizerFile.Add(tokens[3]);
            }
        }
        columnCount = int.Parse((string)(streamID[streamID.Count - 1]));
        textIn.Close();
    }
}

private void outputDialogClick(object sender, EventArgs e)

```

```

{
    if (outputFileDialog.ShowDialog() == DialogResult.OK)
    {
        outputFilePath = outputFileDialog.SelectedPath;
        textOut = new StreamWriter(outputFilePath + "\\system_" + systemName.Text +
            "_throughput.csv");

        textOut.WriteLine("MRQ No." + "\t" + mrqNum.Text);
        textOut.WriteLine("Scenario No." + "\t" + scenarioNum.Text);
        textOut.WriteLine("Clock" + "\t" + dateTimePicker1.Value);
        textOut.WriteLine("");

        for (int i = 0; i <= streamID.Count - 1; i++)
        {
            if (i == 0)
            {
                upstrmName += (string)upstreamName[i] + "\t";
                downstrmName += (string)downstreamName[i] + "\t";
                unitLine += "(gal)" + "\t";
            }

            else if (int.Parse((string)streamID[i]) != int.Parse((string)streamID[i-1]))
            {
                upstrmName += (string)upstreamName[i] + "\t";
                downstrmName += (string)downstreamName[i] + "\t";
                unitLine += "(gal)" + "\t";
            }
        }

        textOut.WriteLine(upstrmName);
        textOut.WriteLine(downstrmName);
        textOut.WriteLine(unitLine);

        //textOut.Close();
    }
}

//Confirm quitting Extractor
private void closingExtractorForm(object sender, FormClosingEventArgs e)
{

```

```

        DialogResult key = MessageBox.Show("Quit TVExtractor", "Confirm", MessageBoxButtons.YesNo,
            MessageBoxIcon.
            Question);
        e.Cancel = (key == DialogResult.No);
    }

private void extractEntireStreamMakeup(object sender, EventArgs e)
{
    int folderCount;
    string outputFilePath = outputFileDialog.SelectedPath;

    volTotal = new double[999, columnCount];
    timeStamp = new string[999];

    //determine totalizer file folders
    if (one.Checked == true)
    {
        folderCount = 1;
    }
    else if (two.Checked == true)
    {
        folderCount = 2;
    }
    else
    {
        folderCount = 3;
    }

    //repeat calculation for totalizer file folders
    for (int folder = 1; folder != folderCount + 1; folder++)
    {
        string totalizerFilePath = ""; //initialize
        if (folder == 1)
        {
            totalizerFilePath = folderDialog1.SelectedPath + "\\ ";
        }
        else if (folder == 2)
        {
            totalizerFilePath = folderDialog2.SelectedPath + "\\ ";
        }
    }
}

```



```

else
{
    totalizerFilePath = folderDialog3.SelectedPath + "\\\";
}

//repeat every totalizer file/combine mass for same stream
int fileCount = 0;
int streamNum;
foreach (string currentFile in totalizerFile)
{
    //update progress status
    progressBar1.Maximum = totalizerFile.Count * folderCount;
    if (folder == 1)
    {
        progressBar1.Value = fileCount;
    }
    else if (folder == 2)
    {
        progressBar1.Value = totalizerFile.Count + fileCount;
    }
    else
    {
        progressBar1.Value = 2 * totalizerFile.Count + fileCount;
    }

    //calculate mass for one file
    streamNum = int.Parse((string)streamID[fileCount]) - 1;
    extractOneFile(streamNum, totalizerFilePath, currentFile);
    fileCount++;
} //End one File

for (int i = 0; i <= rowCount - 1; i++)
{
    oneLine = timeStamp[i] + "\t";
    for (int j = 0; j <= columnCount - 1; j++)
    {
        oneLine += volTotal[i, j] + "\t";
    }

    textOut.WriteLine(oneLine);
}

```

```

    }

    //reset calc arrays
    for (int i = 0; i <= rowCount - 1; i++)
    {
        for (int j = 0; j <= columnCount - 1; j++)
        {
            volTotal[i, j] = 0.0;
        }

        timeStamp[i] = "";
    }

    if (folder == folderCount)
    {
        textOut.Close();
        MessageBox.Show("Totalizer Value Extractor Run Completed!");
    }

} //End Folder

} //End of Entire Flowsheet

private void extractOneFile(int streamNum, string totalizerFilePath, string currentFile)
{
    string[] tokens;
    StreamReader oneFile = new StreamReader(totalizerFilePath + currentFile);

    //skip lines 1 thru 2
    oneLine = oneFile.ReadLine();
    oneLine = oneFile.ReadLine();

    rowCount = 0;
    //repeat monthly data until EOF
    while (oneFile.Peek() > -1)
    {
        //read time stamp
        oneLine = oneFile.ReadLine();
        tokens = oneLine.Split(new char[] { ',' });
    }

```

```
if (tokens.Length == 5)
{
    timeStamp[rowCount] = tokens[1];
}

oneLine = oneFile.ReadLine();

//read total mass
oneLine = oneFile.ReadLine();

//read total volume
oneLine = oneFile.ReadLine();
tokens = oneLine.Split(new char[] { ',', ' ' });
if (tokens.Length == 3)
{
    liqVolTotal = double.Parse(tokens[1]);
    solVolTotal = double.Parse(tokens[2]);
}

volTotal[rowCount, streamNum] = volTotal[rowCount, streamNum] + (liqVolTotal +
    solVolTotal);

rowCount++;

//skip many lines
for (int i = 0; i <= 259; i++)
{
    oneLine = oneFile.ReadLine();
}

} //end repeat till EOF

oneFile.Close();
}

private void showProgress(string fileCreationMessage)
{
    MessageBox.Show("Writing to " + fileCreationMessage, "Click OK to continue");
}
```

```

        private void closingTVEForm(object sender, System.EventArgs e)
        {
            this.Close(); //button close
        }
    } //end Form
}

```

Appendix K

Envelope C Reactions

Appendix K

Envelope C Reactions

Although not in the baseline flowsheet, the Dynamic (G2) Model reserves the capability for performing Envelope C reactions in the UFP1 vessels where strontium and transuranic elements (TRU) are precipitated with the additions of 19M NapOH, 1M NapMnpO₄, and 1M Sr(NO₃)₂. The reactions are tank specific and are shown below:

Reactions Common to AN-102 and AN-107

Reaction	Conversion (Fraction)
Sr+2 (l) + CO ₃ -2 (l) --> Sr+2 (s) + CO ₃ -2 (s)	0.98
90-Sr (l) + CO ₃ -2 (l) --> 90-Sr (s) + CO ₃ -2 (s)	0.98
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 241-Am (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 241-Am (s)	0.86
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 243-Am (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 243-Am (s)	0.86
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 242-Cm (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 242-Cm (s)	0.83
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 243-Cm (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 243-Cm (s)	0.83
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 244-Cm (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 244-Cm (s)	0.83
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 152-Eu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 152-Eu (s)	0.91
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 154-Eu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 154-Eu (s)	0.91
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 155-Eu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 155-Eu (s)	0.91
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 5.5OH- (l) + 237-Np (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 7O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 6H ₂ O (l) + 237-Np (s)	0.78
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 5.5OH- (l) + Pu+4 (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 7O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 6H ₂ O (l) + Pu+4 (s)	0.78
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 238-Pu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 238-Pu (s)	0.78
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 239-Pu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 239-Pu (s)	0.78
14.5Nap+ (l) + 13Mnp (l) + 52O-2 (l) + 10.5Na+ (l) + 6.5CHO ₂ - (l) + 2C ₂ O ₄ -2 (l) + 4.5OH- (l) + 240-Pu (l) --> 14.5Nap+ (l) + 13Mnp (s) + 27O-2 (s) + 6.5O ₂ (g) + 4Na+ (s) + 6.5Na+ (l) + 10.5CO ₃ -2 (l) + 5.5H ₂ O (l) + 240-Pu (s)	0.78

Reaction	Conversion (Fraction)
5.5H ₂ O (l) + 240-Pu (s)	
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 4.5OH ⁻ (l) + 241-Pu (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 6.5O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 5.5H ₂ O (l) + 241-Pu (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 4.5OH ⁻ (l) + 242-Pu (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 6.5O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 5.5H ₂ O (l) + 242-Pu (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 229-Th (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 229-Th (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 231-Pa (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 231-Pa (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 232-Th (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 232-Th (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 232-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 232-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 233-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 233-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 234-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 234-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 235-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 235-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 236-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 236-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 238-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 238-U (s)	0.78
14.5Na ⁺ (l) + 13Mnp (l) + 52O ⁻² (l) + 10.5Na ⁺ (l) + 6.5CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + 5.5OH ⁻ (l) + 238-U (l) --> 14.5Na ⁺ (l) + 13Mnp (s) + 27O ⁻² (s) + 7O ₂ (g) + 4Na ⁺ (s) + 6.5Na ⁺ (l) + 10.5CO ₃ ⁻² (l) + 6H ₂ O (l) + 238-U (s)	0.78
15Na ⁺ (l) + 14Mnp (l) + 56O ⁻² (l) + 11Na ⁺ (l) + 7CHO ₂ ⁻ (l) + 2C ₂ O ₄ ⁻² (l) + OH ⁻ (l) --> 4Na ⁺ (s) + 14Mnp (s) + 27O ⁻² (s) + 7.5O ₂ (g) + 11Na ⁺ (l) + 11Na ⁺ (l) + 11CO ₃ ⁻² (l) + 4H ₂ O (l)	0.99

Reactions Specific to AN-102

Reaction	Conversion (Fraction)
$\text{Al}^{+3} (\text{s}) + 3\text{OH}^{-} (\text{s}) \rightarrow \text{Al}^{+3} (\text{l}) + 3\text{OH}^{-} (\text{l})$	0.72
$\text{Al}^{+3} (\text{s}) + 3\text{OH}(\text{Bound}) (\text{s}) \rightarrow \text{Al}^{+3} (\text{l}) + 3\text{OH}^{-} (\text{l})$	0.72
$\text{Ca}^{+2} (\text{l}) + \text{CO}_3^{-2} (\text{l}) \rightarrow \text{Ca}^{+2} (\text{s}) + \text{CO}_3^{-2} (\text{s})$	0.47
$\text{Cr}(\text{OH}_4)^{-} (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Cr}(\text{OH})_4^{-} (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.33
$\text{Cr}(\text{Total}) (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Cr}(\text{Total}) (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.33
$\text{Fe}^{+3} (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Fe}^{+3} (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.83
$\text{Pb}^{+2} (\text{l}) + \text{CO}_3^{-2} (\text{l}) \rightarrow \text{Pb}^{+2} (\text{s}) + \text{CO}_3^{-2} (\text{s})$	0.17

Reactions Specific to AN-107

Reaction	Conversion (Fraction)
$\text{Al}^{+3} (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Al}^{+3} (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.20
$\text{Ca}^{+2} (\text{l}) + \text{CO}_3^{-2} (\text{l}) \rightarrow \text{Ca}^{+2} (\text{s}) + \text{CO}_3^{-2} (\text{s})$	0.43
$\text{Cr}(\text{OH}_4)^{-} (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Cr}(\text{OH})_4^{-} (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.50
$\text{Cr}(\text{Total}) (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Cr}(\text{Total}) (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.50
$\text{Fe}^{+3} (\text{l}) + 3\text{OH}^{-} (\text{l}) \rightarrow \text{Fe}^{+3} (\text{s}) + 3\text{OH}^{-} (\text{s})$	0.99
$\text{Pb}^{+2} (\text{l}) + \text{CO}_3^{-2} (\text{l}) \rightarrow \text{Pb}^{+2} (\text{s}) + \text{CO}_3^{-2} (\text{s})$	0.60

Appendix L

UFP2 Leaching with Boehmite

Appendix L

UFP2 Leaching with Boehmite

The Dynamic (G2) Model Version 7.0 is designed with the option to perform boehmite leaching in the UFP2 vessels. The boehmite leaching option can be selected by setting the leaching-scenario variable to UFP2 and the boehmite-leaching variable to true on the Model Run Graphic User Interface. The boehmite leaching flowsheet differs from the baseline backend leaching flowsheet in how caustic leach reactions are performed. Operating logic and parameters applied to the boehmite leaching flowsheet are shown in Figures L-1 through L-12. Development of the boehmite leaching logic are discussed in the BARD.

Figure L-1 Boehmite Leaching Decision Logic (Part 1)

Figure L-2 Boehmite Leaching Decision Logic (Part 2)

Figure L-3 Boehmite Leaching Decision Logic (Part 3)

Figure L-4 Boehmite Leaching Decision Logic (Part 4)

Figure L-5 Boehmite Leaching Decision Logic (Part 5)

Figure L-6 Boehmite Leaching Decision Logic (Part 6)

Figure L-7 Boehmite Leaching Decision Logic (Part 7)

Figure L-8 Boehmite Leaching Decision Logic (Part 8)

Figure L-9 Boehmite Leaching Decision Logic (Part 9)

Figure L-10 Boehmite Leaching Decision Logic (Part 10)

Figure L-11 Boehmite Leaching Decision Logic (Part 11)

Figure L-12 Boehmite Leaching Decision Logic (Part 12)

Appendix M

UFP1 Leaching with Gibbsite

Appendix M

UFP1 Leaching with Gibbsite

The Dynamic (G2) Model Version 7.0 is designed with the option to perform caustic leach in the UFP1 vessels (upfront leaching) which can be selected by setting the leaching-scenario variable to UFP1 on the Model Run Graphic User Interface. The upfront leaching flowsheet differs from the baseline backend leaching flowsheet primarily in where caustic leach reactions are performed, but also in feed blending, recycle handling, and solid processes. Operating logic and parameters applied to the upfront leaching flowsheet are described as follows:

Recycle Handling

When the frontend leaching operations are chosen, HLP-VSL-00027A is configured to only receive, store, and transfer FEP evaporator concentrates. A contingency volume is set between the lower set point (31,196 gallons) and the upper set point (85,100 gallons). The vessel can be discharged when its volume is above the lower set point. The vessel can receive and discharge when its volume is within the contingency zone. HLP-VSL-00027A can only be discharged when its volume is above the upper set point. The recycle concentrate in this vessel is used for the feed blending operations described below in this Appendix.

Feed Blending

Feed blending logic are implemented in the UFP1 vessels to: a) improve the uniformity of ultrafiltration feeds, b) better balance the overall utilization of LAW and HLW feeds, and c) alleviate the pressure of water lock on the recycle loop. Normal feed blending is performed by filling a UFP1 vessel with a pre-determined volume of HLW feed then topping it off with recycled concentrate or LAW feed. Other feed blendings include those described below:

- 1) When a UFP1 vessel becomes “empty”, it will receive feeds from upstream sources in the following order: a) HLW feed from HLP-VSL-00022, b) recycle concentrate from HLP-VSL-00027A, or c) LAW feed from FRP-VSL-00002A/B/C/D. It will use the next priority feed if the higher priority feed is not available at the time of request.
- 2) When HLW feed is delivered to the UFP1 vessel, the mass of gibbsite will be determined. The transfer will stop if 25 kg-moles of $\text{Al}(\text{OH})_3$ has been accumulated in the vessel which will then be topped off to its set volume with recycle concentrate or LAW feed. The set volume of the UFP1 vessel is 28,300 gallons.
- 3) The UFP1 vessel will be filled with HLW feed to its set volume if the 25 kg-moles of $\text{Al}(\text{OH})_3$ goal is not reached. When this happens, topping off the vessel with recycle concentrate or LAW feed is not required.
- 4) If the UFP1 vessel reaches the 25 kg-mole $\text{Al}(\text{OH})_3$ goal before it fills to the set volume and no recycle concentrate and LAW feed are available at the time, the UFP1 vessel will be set to perform the caustic leach operations.
- 5) To achieve a better balance for the use of LAW and HLW feeds, a LAW batch will be sent through the UFP system without blending in the beginning of each UFP2 cycle. The LAW feed will be transferred to the available UFP1 vessel to its set volume at 28,300 gallons.

- 6) To alleviate the pressure of water lock on the recycle loop, an upper set volume is placed in HLP-VSL-00027A at 84,584 gallons, when reached will trigger a discharge, e.g., the next available UFP1 vessel will receive a full batch of recycle concentrate.

Line flush is received in the UFP1 vessel after each batch transfer from HLP-VSL-00022, HLP-VSL-00027A, or FRP-VSL-00002A/B/C/D. Caustic leach decisions will be made based on the waste compositions in the vessel.

Caustic Leach

Generally caustic leach can reduce the HLW glass produced as most of the WTP solids are aluminum limiting. For waste batches that are limited by other Specification 1 species, caustic leach is unnecessary as it increases processing time and add sodium to the plant. A caustic leach decision logic has been developed by the WTP Process Engineering and Technology Department that determines if a waste batch is aluminum limiting and consequently if the caustic leach can reduce HLW glass by 10% or more. Wash factors as well as the subsequent oxidative leach have also been considered. Figures 5 through 8 in Section 4.8.3 provide a logic diagram that determines if caustic leach is required for the waste batch. The following actions could take place depending on the caustic leach decisions:

- 1) The feed will be heated, caustic leached, and cooled, or
- 2) The feed will be adjusted for sodium concentration by dilution and hydroxide concentration by caustic addition.

Caustic leach operations include heating, reaction, and cooling. A pre-determined volume of 19M NaOH (Na = waste sodium) will also be added during heating. Vessel contents will be heated to 85 °C with a steam condensate volume and a heating time determined by Equations L-1 and L-2, respectively.

$$V_S = 9,000 * (V_W + V_{ACV}) / 39,000 \quad (\text{Eq. L-1})$$

$$T_H = 9 * (V_W + V_{ACV}) / 39,000 \quad (\text{Eq. L-2})$$

Where:

V_S = Steam condensate volume (gallons)
 V_W = Waste volume before heating (gallons)
 V_{ACV} = Average caustic volume (gallons)
 T_H = Heating time (hours)

The average caustic volume (2,133 gallons) is obtained by averaging the values for the entire mission from a trial run. The caustic volume for leaching is determined based on Equation 13 with an additional 10% margin to account for dilution later during wash. The heated solutions are allowed to react for 8 hours during which an additional 400 gallons of steam condensate is added to maintain temperature. Leaching reactions are the same as those discussed in the backend leaching flowsheet in Section 4.8.3. Cooling takes 2 hours. Steam and chill water supply can support parallel heating and parallel cooling operations in the two UFP1 vessels.

For waste batches not requiring caustic leach, water will be added if necessary to lower sodium concentration to 6M. Caustic (19M) will also be added if necessary to keep hydroxide concentration to

above 0.5M. Vessel contents will be heated to 45 °C with a steam condensate volume and a heating time determined by Equations 28 and 29, respectively. Solubility is applied at 45 °C after pre-heating.

Solid Processes

Set volumes of the UFP2 vessels are placed at 19,000 gallons, e.g., solid concentration is achieved in an 1000-gallon increment between 18,000 – 19,000 gallons. Solid concentration stops when the 20 wt% target value is reached. Solid wash, oxidative leach, and oxidative wash processes are the same as those backend leaching flowsheet, but treated solids can only be discharged to HLP-VSL-00027B.

Appendix N

Totalizer Files

Appendix N

Totalizer Files

The totalizer data provides the cumulative mass in kilograms for every process stream in a 30-day time interval. The process streams are identified by the following convention: “upstream_downstream”. The data includes the mass in the liquid phase, solid phase, gas phase, and in the oxide form as appropriate. Table N-1 provides a summary of totalizer files available for Dynamic (G2) Model Version 7.0.

Table N-1 G2 Version 6.0 Totalizer Files

Upstream Equipment	Downstream Equipment	Totalizer File
RDP-VSL-00002A	PJM-RFD-VENT	RDP-VSL-00002A_PJM-RFD-VENT
RDP-VSL-00002A	CXP-IXC-00004	RDP-VSL-00002A_CXP-IXC-00004
RDP-VSL-00002A	CXP-IXC-00003	RDP-VSL-00002A_CXP-IXC-00003
RDP-VSL-00002A	CXP-IXC-00002	RDP-VSL-00002A_CXP-IXC-00002
RDP-VSL-00002A	CXP-IXC-00001	RDP-VSL-00002A_CXP-IXC-00001
RDP-VSL-00002A-CAUSTIC	RDP-VSL-00002A	RDP-VSL-00002A-CAUSTIC_RDP-VSL-00002A
NAR-MXR-00003	CRP-VSL-00001	NAR-MXR-00003_CRP-VSL-00001
SHR-TK-00004	CRP-VSL-00001	SHR-TK-00004_CRP-VSL-00001
DIW-TK-00004	CRP-VSL-00001	DIW-TK-00004_CRP-VSL-00001
CRP-VSL-00001	CXP-IXC-00004	CRP-VSL-00001_CXP-IXC-00004
CRP-VSL-00001	CXP-IXC-00003	CRP-VSL-00001_CXP-IXC-00003
CRP-VSL-00001	CXP-IXC-00002	CRP-VSL-00001_CXP-IXC-00002
CRP-VSL-00001	CXP-IXC-00001	CRP-VSL-00001_CXP-IXC-00001
CRP-VSL-00001	RLD-VSL-00017A	CRP-VSL-00001_RLD-VSL-00017A
CRP-VSL-00001	RLD-VSL-00017B	CRP-VSL-00001_RLD-VSL-00017B
RDP-VSL-00002B	PJM-RFD-VENT	RDP-VSL-00002B_PJM-RFD-VENT
RDP-VSL-00002B	FEP-VSL-00017B	RDP-VSL-00002B_FEP-VSL-00017B
RDP-VSL-00002B	FEP-VSL-00017A	RDP-VSL-00002B_FEP-VSL-00017A
RDP-VSL-00002B	RDP-VSL-00002C	RDP-VSL-00002B_RDP-VSL-00002C
RDP-VSL-00002B	RESIN-DISPOSAL	RDP-VSL-00002B_RESIN-DISPOSAL
RDP-VSL-00002B	RDP-VSL-00002A	RDP-VSL-00002B_RDP-VSL-00002A
RDP-VSL-00002C	PJM-RFD-VENT	RDP-VSL-00002C_PJM-RFD-VENT
RDP-VSL-00002C	FEP-VSL-00017B	RDP-VSL-00002C_FEP-VSL-00017B
RDP-VSL-00002C	FEP-VSL-00017A	RDP-VSL-00002C_FEP-VSL-00017A
RF-RESIN	CRP-VSL-00001	RF-RESIN_CRP-VSL-00001
TLP-INTER-AFTER-CONDENSER-WATER	TLP-VSL-00002	TLP-INTER-AFTER-CONDENSER-WATER_TLP-VSL-00002
TLP-SEP-00001	TLP-DMST-00001	TLP-SEP-00001_TLP-DMST-00001
TLP-SEP-00001	TCP-VSL-00001	TLP-SEP-00001_TCP-VSL-00001
CXP-VSL-00026A	PJM-RFD-VENT	CXP-VSL-00026A_PJM-RFD-VENT
CXP-VSL-00026A	TLP-SEP-00001	CXP-VSL-00026A_TLP-SEP-00001
CXP-VSL-00026C	PJM-RFD-VENT	CXP-VSL-00026C_PJM-RFD-VENT
CXP-VSL-00026C	TLP-SEP-00001	CXP-VSL-00026C_TLP-SEP-00001
CXP-VSL-00026B	PJM-RFD-VENT	CXP-VSL-00026B_PJM-RFD-VENT
CXP-VSL-00026B	TLP-SEP-00001	CXP-VSL-00026B_TLP-SEP-00001
TCP-VSL-00001	PJM-RFD-VENT	TCP-VSL-00001_PJM-RFD-VENT

Upstream Equipment	Downstream Equipment	Totalizer File
TCP-VSL-00001	LCP-VSL-00001	TCP-VSL-00001_LCP-VSL-00001
TCP-VSL-00001	SUPPLEMENTAL-LAW-TREATED	TCP-VSL-00001_SUPPLEMENTAL-LAW-TREATED
TCP-VSL-00001	LCP-VSL-00002	TCP-VSL-00001_LCP-VSL-00002
TLP-VSL-00002	RLD-TK-00006A	TLP-VSL-00002_RLD-TK-00006A
TLP-DMST-00001	TLP-VSL-00002	TLP-DMST-00001_TLP-VSL-00002
TLP-DMST-00001	PVP-VESSEL-VENT	TLP-DMST-00001_PVP-VESSEL-VENT
TLP-DMST-00001-AIR	TLP-DMST-00001	TLP-DMST-00001-AIR_TLP-DMST-00001
TLP-VSL-00009A	PJM-RFD-VENT	TLP-VSL-00009A_PJM-RFD-VENT
TLP-VSL-00009A	TLP-SEP-00001	TLP-VSL-00009A_TLP-SEP-00001
SHR-TK-00007	TLP-VSL-00009A	SHR-TK-00007_TLP-VSL-00009A
TLP-VSL-00009B	PJM-RFD-VENT	TLP-VSL-00009B_PJM-RFD-VENT
TLP-VSL-00009B	TLP-SEP-00001	TLP-VSL-00009B_TLP-SEP-00001
SHR-TK-00007	TLP-VSL-00009B	SHR-TK-00007_TLP-VSL-00009B
RLD-TK-00006A	HLP-VSL-00027B	RLD-TK-00006A_HLP-VSL-00027B
RLD-TK-00006A	HLP-VSL-00027A	RLD-TK-00006A_HLP-VSL-00027A
RLD-TK-00006A	HLP-VSL-00028	RLD-TK-00006A_HLP-VSL-00028
RLD-TK-00006A	PWD-VSL-00033	RLD-TK-00006A_PWD-VSL-00033
RLD-TK-00006A	PWD-VSL-00043	RLD-TK-00006A_PWD-VSL-00043
RLD-TK-00006A	TCP-VSL-00001	RLD-TK-00006A_TCP-VSL-00001
RLD-TK-00006A	RDP-VSL-00002B	RLD-TK-00006A_RDP-VSL-00002B
RLD-TK-00006A	TLP-SEP-00001	RLD-TK-00006A_TLP-SEP-00001
RLD-TK-00006A	TLP-VSL-00009A	RLD-TK-00006A_TLP-VSL-00009A
RLD-TK-00006A	TLP-VSL-00009B	RLD-TK-00006A_TLP-VSL-00009B
RLD-TK-00006A	SUPPLEMENTAL-LAW-RECYCLE	RLD-TK-00006A_SUPPLEMENTAL-LAW-RECYCLE
RLD-TK-00006A	CXP-VSL-00026A	RLD-TK-00006A_CXP-VSL-00026A
RLD-TK-00006A	CXP-VSL-00026C	RLD-TK-00006A_CXP-VSL-00026C
RLD-TK-00006A	CXP-VSL-00026B	RLD-TK-00006A_CXP-VSL-00026B
RLD-TK-00006A	UFP-VSL-00062A	RLD-TK-00006A_UFP-VSL-00062A
RLD-TK-00006A	UFP-VSL-00002A	RLD-TK-00006A_UFP-VSL-00002A
RLD-TK-00006A	UFP-VSL-00001A	RLD-TK-00006A_UFP-VSL-00001A
RLD-TK-00006A	UFP-VSL-00002B	RLD-TK-00006A_UFP-VSL-00002B
RLD-TK-00006A	UFP-VSL-00001B	RLD-TK-00006A_UFP-VSL-00001B
RLD-TK-00006A	FEP-VSL-00017B	RLD-TK-00006A_FEP-VSL-00017B
RLD-TK-00006A	FEP-VSL-00017A	RLD-TK-00006A_FEP-VSL-00017A
RLD-TK-00006A	FEP-SEP-00001A	RLD-TK-00006A_FEP-SEP-00001A
RLD-TK-00006A	FEP-SEP-00001B	RLD-TK-00006A_FEP-SEP-00001B
RLD-TK-00006A	FRP-VSL-00002D	RLD-TK-00006A_FRP-VSL-00002D
RLD-TK-00006A	FRP-VSL-00002C	RLD-TK-00006A_FRP-VSL-00002C
RLD-TK-00006A	FRP-VSL-00002B	RLD-TK-00006A_FRP-VSL-00002B
RLD-TK-00006A	FRP-VSL-00002A	RLD-TK-00006A_FRP-VSL-00002A
RLD-TK-00006A	HLP-VSL-00022	RLD-TK-00006A_HLP-VSL-00022
RLD-TK-00006A	RLD-TK-00006B	RLD-TK-00006A_RLD-TK-00006B
RLD-TK-00006B	ETF-1	RLD-TK-00006B ETF-1
RLD-VSL-00017A	RLD-TK-00006B	RLD-VSL-00017A_RLD-TK-00006B
RLD-VSL-00017B	RLD-TK-00006B	RLD-VSL-00017B_RLD-TK-00006B

Upstream Equipment	Downstream Equipment	Totalizer File
UFP-VSL-00002B	UFP-VSL-00002A	UFP-VSL-00002B_UFP-VSL-00002A
UFP-VSL-00002B	PWD-VSL-00015	UFP-VSL-00002B_PWD-VSL-00015
UFP-VSL-00002B	PWD-VSL-00016	UFP-VSL-00002B_PWD-VSL-00016
UFP-VSL-00002B	HLP-VSL-00027B	UFP-VSL-00002B_HLP-VSL-00027B
UFP-VSL-00002B	HLP-VSL-00027A	UFP-VSL-00002B_HLP-VSL-00027A
UFP-VSL-00002B	PJM-RFD-VENT	UFP-VSL-00002B_PJM-RFD-VENT
UFP-VSL-00002B	UFP-02B-P1	UFP-VSL-00002B_UFP-02B-P1
UFP-VSL-00002A	UFP-02A-P1	UFP-VSL-00002A_UFP-02A-P1
UFP-VSL-00002A	PWD-VSL-00015	UFP-VSL-00002A_PWD-VSL-00015
UFP-VSL-00002A	PWD-VSL-00016	UFP-VSL-00002A_PWD-VSL-00016
UFP-VSL-00002A	HLP-VSL-00027B	UFP-VSL-00002A_HLP-VSL-00027B
UFP-VSL-00002A	HLP-VSL-00027A	UFP-VSL-00002A_HLP-VSL-00027A
UFP-VSL-00002A	PJM-RFD-VENT	UFP-VSL-00002A_PJM-RFD-VENT
NAR-TK-00006	UFP-VSL-00002A	NAR-TK-00006_UFP-VSL-00002A
NAR-TK-00006	UFP-VSL-00002B	NAR-TK-00006_UFP-VSL-00002B
SPR-MXR-00001	UFP-VSL-00001A	SPR-MXR-00001_UFP-VSL-00001A
STR-MXR-00001	UFP-VSL-00001A	STR-MXR-00001_UFP-VSL-00001A
SPR-MXR-00001	UFP-VSL-00001B	SPR-MXR-00001_UFP-VSL-00001B
STR-MXR-00001	UFP-VSL-00001B	STR-MXR-00001_UFP-VSL-00001B
UFP-VSL-00062A	CXP-FILT-00001	UFP-VSL-00062A_CXP-FILT-00001
UFP-VSL-00062A	PJM-RFD-VENT	UFP-VSL-00062A_PJM-RFD-VENT
UFP-VSL-00062B	PJM-RFD-VENT	UFP-VSL-00062B_PJM-RFD-VENT
UFP-VSL-00001A	PJM-RFD-VENT	UFP-VSL-00001A_PJM-RFD-VENT
UFP-VSL-00001A	UFP-VSL-00002A	UFP-VSL-00001A_UFP-VSL-00002A
UFP-VSL-00001A	UFP-VSL-00002B	UFP-VSL-00001A_UFP-VSL-00002B
UFP-VSL-00001B	PJM-RFD-VENT	UFP-VSL-00001B_PJM-RFD-VENT
UFP-VSL-00001B	UFP-VSL-00002B	UFP-VSL-00001B_UFP-VSL-00002B
UFP-VSL-00001B	UFP-VSL-00002A	UFP-VSL-00001B_UFP-VSL-00002A
STEAM	UFP-VSL-00062A	STEAM_UFP-VSL-00062A
STEAM	UFP-VSL-00002A	STEAM_UFP-VSL-00002A
STEAM	UFP-VSL-00001A	STEAM_UFP-VSL-00001A
STEAM	UFP-VSL-00002B	STEAM_UFP-VSL-00002B
STEAM	UFP-VSL-00001B	STEAM_UFP-VSL-00001B
UFP-VSL-00062C	PJM-RFD-VENT	UFP-VSL-00062C_PJM-RFD-VENT
UFP-02A-P1	UFP-02A-P2	UFP-02A-P1_UFP-02A-P2
UFP-02A-P2	PWD-VSL-00033	UFP-02A-P2_PWD-VSL-00033
UFP-02A-P2	UFP-VSL-00002A	UFP-02A-P2_UFP-VSL-00002A
UFP-02A-P2	PWD-VSL-00015	UFP-02A-P2_PWD-VSL-00015
UFP-02A-P2	PWD-VSL-00016	UFP-02A-P2_PWD-VSL-00016
UFP-02A-P2	UFP-VSL-00062A	UFP-02A-P2_UFP-VSL-00062A
UFP-02-P2-NAOH	UFP-02A-P2	UFP-02-P2-NAOH_UFP-02A-P2
UFP-02B-P1	UFP-02B-P2	UFP-02B-P1_UFP-02B-P2
UFP-02B-P2	PWD-VSL-00033	UFP-02B-P2_PWD-VSL-00033
UFP-02B-P2	UFP-VSL-00002B	UFP-02B-P2_UFP-VSL-00002B
UFP-02B-P2	PWD-VSL-00015	UFP-02B-P2_PWD-VSL-00015
UFP-02B-P2	PWD-VSL-00016	UFP-02B-P2_PWD-VSL-00016
UFP-02B-P2	UFP-VSL-00062A	UFP-02B-P2_UFP-VSL-00062A

Upstream Equipment	Downstream Equipment	Totalizer File
UFP-02-P2-NAOH	UFP-02B-P2	UFP-02-P2-NAOH_UFP-02B-P2
SPR-MXR-00001	UFP-VSL-00002A	SPR-MXR-00001_UFP-VSL-00002A
SPR-MXR-00001	UFP-VSL-00002B	SPR-MXR-00001_UFP-VSL-00002B
SHR-TK-00006	UFP-VSL-00062A	SHR-TK-00006_UFP-VSL-00062A
SHR-TK-00006	UFP-VSL-00002A	SHR-TK-00006_UFP-VSL-00002A
SHR-TK-00006	UFP-VSL-00001A	SHR-TK-00006_UFP-VSL-00001A
SHR-TK-00006	UFP-VSL-00002B	SHR-TK-00006_UFP-VSL-00002B
SHR-TK-00006	UFP-VSL-00001B	SHR-TK-00006_UFP-VSL-00001B
NEUTRALIZATION-CAUSTIC	UFP-VSL-00002A	NEUTRALIZATION-CAUSTIC_UFP-VSL-00002A
NEUTRALIZATION-CAUSTIC	UFP-VSL-00002B	NEUTRALIZATION-CAUSTIC_UFP-VSL-00002B
OXIDATIVE-LEACH-CAUSTIC	UFP-VSL-00002A	OXIDATIVE-LEACH-CAUSTIC_UFP-VSL-00002A
OXIDATIVE-LEACH-CAUSTIC	UFP-VSL-00002B	OXIDATIVE-LEACH-CAUSTIC_UFP-VSL-00002B
DIW-TK-00001	RDP-VSL-00002B	DIW-TK-00001_RDP-VSL-00002B
DIW-TK-00001	RDP-VSL-00002A	DIW-TK-00001_RDP-VSL-00002A
DIW-TK-00001	HLP-VSL-00027B	DIW-TK-00001_HLP-VSL-00027B
DIW-TK-00001	HLP-VSL-00027A	DIW-TK-00001_HLP-VSL-00027A
DIW-TK-00001	HLP-VSL-00028	DIW-TK-00001_HLP-VSL-00028
DIW-TK-00001	PWD-VSL-00033	DIW-TK-00001_PWD-VSL-00033
DIW-TK-00001	PWD-VSL-00043	DIW-TK-00001_PWD-VSL-00043
DIW-TK-00001	TCP-VSL-00001	DIW-TK-00001_TCP-VSL-00001
DIW-TK-00001	TLP-SEP-00001	DIW-TK-00001_TLP-SEP-00001
DIW-TK-00001	TLP-VSL-00009A	DIW-TK-00001_TLP-VSL-00009A
DIW-TK-00001	TLP-VSL-00009B	DIW-TK-00001_TLP-VSL-00009B
DIW-TK-00001	SUPPLEMENTAL-LAW-RECYCLE	DIW-TK-00001_SUPPLEMENTAL-LAW-RECYCLE
DIW-TK-00001	CXP-VSL-00026A	DIW-TK-00001_CXP-VSL-00026A
DIW-TK-00001	CXP-VSL-00026C	DIW-TK-00001_CXP-VSL-00026C
DIW-TK-00001	CXP-VSL-00026B	DIW-TK-00001_CXP-VSL-00026B
DIW-TK-00001	CXP-IXC-00004	DIW-TK-00001_CXP-IXC-00004
DIW-TK-00001	CXP-IXC-00003	DIW-TK-00001_CXP-IXC-00003
DIW-TK-00001	CXP-IXC-00002	DIW-TK-00001_CXP-IXC-00002
DIW-TK-00001	CXP-IXC-00001	DIW-TK-00001_CXP-IXC-00001
DIW-TK-00001	UFP-VSL-00062A	DIW-TK-00001_UFP-VSL-00062A
DIW-TK-00001	UFP-VSL-00002A	DIW-TK-00001_UFP-VSL-00002A
DIW-TK-00001	UFP-VSL-00001A	DIW-TK-00001_UFP-VSL-00001A
DIW-TK-00001	UFP-VSL-00002B	DIW-TK-00001_UFP-VSL-00002B
DIW-TK-00001	UFP-VSL-00001B	DIW-TK-00001_UFP-VSL-00001B
DIW-TK-00001	FEP-VSL-00017B	DIW-TK-00001_FEP-VSL-00017B
DIW-TK-00001	FEP-VSL-00017A	DIW-TK-00001_FEP-VSL-00017A
DIW-TK-00001	FEP-SEP-00001A	DIW-TK-00001_FEP-SEP-00001A
DIW-TK-00001	FEP-SEP-00001B	DIW-TK-00001_FEP-SEP-00001B
DIW-TK-00001	FRP-VSL-00002D	DIW-TK-00001_FRP-VSL-00002D
DIW-TK-00001	FRP-VSL-00002C	DIW-TK-00001_FRP-VSL-00002C
DIW-TK-00001	FRP-VSL-00002B	DIW-TK-00001_FRP-VSL-00002B

Upstream Equipment	Downstream Equipment	Totalizer File
DIW-TK-00001	FRP-VSL-00002A	DIW-TK-00001_FRP-VSL-00002A
DIW-TK-00001	HLP-VSL-00022	DIW-TK-00001_HLP-VSL-00022
DIW-TK-00001	HDH-VSL-00003	DIW-TK-00001_HDH-VSL-00003
DIW-TK-00001	LCP-VSL-00002	DIW-TK-00001_LCP-VSL-00002
DIW-TK-00001	LCP-VSL-00001	DIW-TK-00001_LCP-VSL-00001
DIW-TK-00001	LFP-VSL-00003	DIW-TK-00001_LFP-VSL-00003
DIW-TK-00001	LFP-VSL-00001	DIW-TK-00001_LFP-VSL-00001
DIW-TK-00001	LFP-VSL-00004	DIW-TK-00001_LFP-VSL-00004
DIW-TK-00001	LFP-VSL-00002	DIW-TK-00001_LFP-VSL-00002
DIW-TK-00001	LMP-MLTR-00002	DIW-TK-00001_LMP-MLTR-00002
DIW-TK-00001	LMP-MLTR-00001	DIW-TK-00001_LMP-MLTR-00001
DIW-TK-00001	RLD-VSL-00007	DIW-TK-00001_RLD-VSL-00007
DIW-TK-00001	HFP-VSL-00005	DIW-TK-00001_HFP-VSL-00005
DIW-TK-00001	HFP-VSL-00001	DIW-TK-00001_HFP-VSL-00001
DIW-TK-00001	HFP-VSL-00006	DIW-TK-00001_HFP-VSL-00006
DIW-TK-00001	HFP-VSL-00002	DIW-TK-00001_HFP-VSL-00002
INHIBITED-WATER	PWD-VSL-00033	INHIBITED-WATER_PWD-VSL-00033
INHIBITED-WATER	PWD-VSL-00043	INHIBITED-WATER_PWD-VSL-00043
INHIBITED-WATER	UFP-02A-P2	INHIBITED-WATER_UFP-02A-P2
INHIBITED-WATER	UFP-02B-P2	INHIBITED-WATER_UFP-02B-P2
INHIBITED-WATER	UFP-02A-P1	INHIBITED-WATER_UFP-02A-P1
INHIBITED-WATER	UFP-02B-P1	INHIBITED-WATER_UFP-02B-P1
INHIBITED-WATER	UFP-VSL-00002B	INHIBITED-WATER_UFP-VSL-00002B
INHIBITED-WATER	UFP-VSL-00002A	INHIBITED-WATER_UFP-VSL-00002A
INHIBITED-WATER	HLP-VSL-00027B	INHIBITED-WATER_HLP-VSL-00027B
INHIBITED-WATER	HLP-VSL-00027A	INHIBITED-WATER_HLP-VSL-00027A
INHIBITED-WATER	HLP-VSL-00028	INHIBITED-WATER_HLP-VSL-00028
INHIBITED-WATER	FRP-VSL-00002D	INHIBITED-WATER_FRP-VSL-00002D
INHIBITED-WATER	FRP-VSL-00002C	INHIBITED-WATER_FRP-VSL-00002C
INHIBITED-WATER	FRP-VSL-00002B	INHIBITED-WATER_FRP-VSL-00002B
INHIBITED-WATER	FRP-VSL-00002A	INHIBITED-WATER_FRP-VSL-00002A
INHIBITED-WATER	HLP-VSL-00022	INHIBITED-WATER_HLP-VSL-00022
ANTIFOAM-AGENT	TLP-SEP-00001	ANTIFOAM-AGENT_TLP-SEP-00001
ANTIFOAM-AGENT	HLP-VSL-00027B	ANTIFOAM-AGENT_HLP-VSL-00027B
ANTIFOAM-AGENT	HLP-VSL-00027A	ANTIFOAM-AGENT_HLP-VSL-00027A
ANTIFOAM-AGENT	HLP-VSL-00028	ANTIFOAM-AGENT_HLP-VSL-00028
ANTIFOAM-AGENT	UFP-VSL-00002A	ANTIFOAM-AGENT_UFP-VSL-00002A
ANTIFOAM-AGENT	UFP-VSL-00002B	ANTIFOAM-AGENT_UFP-VSL-00002B
ANTIFOAM-AGENT	UFP-VSL-00001A	ANTIFOAM-AGENT_UFP-VSL-00001A
ANTIFOAM-AGENT	UFP-VSL-00001B	ANTIFOAM-AGENT_UFP-VSL-00001B
ANTIFOAM-AGENT	FEP-SEP-00001B	ANTIFOAM-AGENT_FEP-SEP-00001B
ANTIFOAM-AGENT	FEP-SEP-00001A	ANTIFOAM-AGENT_FEP-SEP-00001A
LFP-VSL-00003-MIXER	LFP-VSL-00003	LFP-VSL-00003-MIXER_LFP-VSL-00003
RUTILE	SYSTEM-500-WEIGH-HOPPER	RUTILE_SYSTEM-500-WEIGH-HOPPER
OLIVINE	SYSTEM-500-WEIGH-HOPPER	OLIVINE_SYSTEM-500-WEIGH-HOPPER

Upstream Equipment	Downstream Equipment	Totalizer File
ZIRCON-SAND	SYSTEM-500-WEIGH-HOPPER	ZIRCON-SAND_SYSTEM-500-WEIGH-HOPPER
IRON-OXIDE	SYSTEM-500-WEIGH-HOPPER	IRON-OXIDE_SYSTEM-500-WEIGH-HOPPER
SILICA	SYSTEM-100-WEIGH-HOPPER	SILICA_SYSTEM-100-WEIGH-HOPPER
WOLLASTONITE	SYSTEM-200-WEIGH-HOPPER	WOLLASTONITE_SYSTEM-200-WEIGH-HOPPER
KYANITE	SYSTEM-200-WEIGH-HOPPER	KYANITE_SYSTEM-200-WEIGH-HOPPER
BORIC-ACID	SYSTEM-200-WEIGH-HOPPER	BORIC-ACID_SYSTEM-200-WEIGH-HOPPER
SUGAR	SYSTEM-200-WEIGH-HOPPER	SUGAR_SYSTEM-200-WEIGH-HOPPER
SYSTEM-100-WEIGH-HOPPER	SYSTEM-100-TRANSPORTER	SYSTEM-100-WEIGH-HOPPER_SYSTEM-100-TRANSPORTER
SYSTEM-500-WEIGH-HOPPER	SYSTEM-500-TRANSPORTER	SYSTEM-500-WEIGH-HOPPER_SYSTEM-500-TRANSPORTER
SYSTEM-200-WEIGH-HOPPER	SYSTEM-200-TRANSPORTER	SYSTEM-200-WEIGH-HOPPER_SYSTEM-200-TRANSPORTER
SYSTEM-500-TRANSPORTER	LAW-BLENDING-SILO	SYSTEM-500-TRANSPORTER_LAW-BLENDING-SILO
SYSTEM-500-TRANSPORTER	HLW-BLENDING-SILO	SYSTEM-500-TRANSPORTER_HLW-BLENDING-SILO
SYSTEM-100-TRANSPORTER	LAW-BLENDING-SILO	SYSTEM-100-TRANSPORTER_LAW-BLENDING-SILO
SYSTEM-100-TRANSPORTER	HLW-BLENDING-SILO	SYSTEM-100-TRANSPORTER_HLW-BLENDING-SILO
SYSTEM-200-TRANSPORTER	LAW-BLENDING-SILO	SYSTEM-200-TRANSPORTER_LAW-BLENDING-SILO
SYSTEM-200-TRANSPORTER	HLW-BLENDING-SILO	SYSTEM-200-TRANSPORTER_HLW-BLENDING-SILO
HLW-BLENDING-SILO	HLW-TRANSPORTER	HLW-BLENDING-SILO_HLW-TRANSPORTER
LAW-BLENDING-SILO	LAW-TRANSPORTER	LAW-BLENDING-SILO_LAW-TRANSPORTER
HLW-TRANSPORTER	HFP-VSL-00005-MIXER	HLW-TRANSPORTER_HFP-VSL-00005-MIXER
HLW-TRANSPORTER	HFP-VSL-00001-MIXER	HLW-TRANSPORTER_HFP-VSL-00001-MIXER
LITHIUM-CARBONATE	SYSTEM-300-WEIGH-HOPPER	LITHIUM-CARBONATE_SYSTEM-300-WEIGH-HOPPER
ZINC-OXIDE	SYSTEM-300-WEIGH-HOPPER	ZINC-OXIDE_SYSTEM-300-WEIGH-HOPPER
SODA-ASH	SYSTEM-400-WEIGH-HOPPER	SODA-ASH_SYSTEM-400-WEIGH-HOPPER
BORAX	SYSTEM-400-WEIGH-HOPPER	BORAX_SYSTEM-400-WEIGH-HOPPER
SYSTEM-300-WEIGH-HOPPER	SYSTEM-300-TRANSPORTER	SYSTEM-300-WEIGH-HOPPER_SYSTEM-300-TRANSPORTER
SYSTEM-400-WEIGH-HOPPER	SYSTEM-400-TRANSPORTER	SYSTEM-400-WEIGH-HOPPER_SYSTEM-400-TRANSPORTER
LAW-TRANSPORTER	LFP-VSL-00003-MIXER	LAW-TRANSPORTER_LFP-VSL-00003-MIXER
LAW-TRANSPORTER	LFP-VSL-00001-MIXER	LAW-TRANSPORTER_LFP-VSL-00001-MIXER
SYSTEM-300-TRANSPORTER	LAW-BLENDING-SILO	SYSTEM-300-TRANSPORTER_LAW-BLENDING-SILO

Upstream Equipment	Downstream Equipment	Totalizer File
SYSTEM-300-TRANSPORTER	HLW-BLENDING-SILO	SYSTEM-300-TRANSPORTER_HLW-BLENDING-SILO
SYSTEM-400-TRANSPORTER	LAW-BLENDING-SILO	SYSTEM-400-TRANSPORTER_LAW-BLENDING-SILO
SYSTEM-400-TRANSPORTER	HLW-BLENDING-SILO	SYSTEM-400-TRANSPORTER_HLW-BLENDING-SILO
DUSTING-WATER	HFP-VSL-00001-MIXER	DUSTING-WATER_HFP-VSL-00001-MIXER
DUSTING-WATER	HFP-VSL-00005-MIXER	DUSTING-WATER_HFP-VSL-00005-MIXER
DUSTING-WATER	LFP-VSL-00003-MIXER	DUSTING-WATER_LFP-VSL-00003-MIXER
DUSTING-WATER	LFP-VSL-00001-MIXER	DUSTING-WATER_LFP-VSL-00001-MIXER
HFP-VSL-00001-MIXER	HFP-VSL-00001	HFP-VSL-00001-MIXER_HFP-VSL-00001
HFP-VSL-00005-MIXER	HFP-VSL-00005	HFP-VSL-00005-MIXER_HFP-VSL-00005
LFP-VSL-00001-MIXER	LFP-VSL-00001	LFP-VSL-00001-MIXER_LFP-VSL-00001
LCP-VSL-00001	SUPPLEMENTAL-LAW-TREATED	LCP-VSL-00001_SUPPLEMENTAL-LAW-TREATED
LCP-VSL-00001	LFP-VSL-00001	LCP-VSL-00001_LFP-VSL-00001
LCP-VSL-00001	LFP-VSL-00003	LCP-VSL-00001_LFP-VSL-00003
LCP-VSL-00002	SUPPLEMENTAL-LAW-TREATED	LCP-VSL-00002_SUPPLEMENTAL-LAW-TREATED
LCP-VSL-00002	LFP-VSL-00001	LCP-VSL-00002_LFP-VSL-00001
LCP-VSL-00002	LFP-VSL-00003	LCP-VSL-00002_LFP-VSL-00003
LFP-VSL-00003	LFP-VSL-00004	LFP-VSL-00003_LFP-VSL-00004
LFP-VSL-00002	LMP-MLTR-00001	LFP-VSL-00002_LMP-MLTR-00001
LFP-VSL-00004	LMP-MLTR-00002	LFP-VSL-00004_LMP-MLTR-00002
LFP-VSL-00001	LFP-VSL-00002	LFP-VSL-00001_LFP-VSL-00002
RHEOLOGY-WATER	LFP-VSL-00001	RHEOLOGY-WATER_LFP-VSL-00001
RHEOLOGY-WATER	LFP-VSL-00003	RHEOLOGY-WATER_LFP-VSL-00003
HLP-VSL-00027B	PJM-RFD-VENT	HLP-VSL-00027B_PJM-RFD-VENT
HLP-VSL-00027B	HLP-VSL-00028	HLP-VSL-00027B_HLP-VSL-00028
HLP-VSL-00027A	PJM-RFD-VENT	HLP-VSL-00027A_PJM-RFD-VENT
HLP-VSL-00027A	HLP-VSL-00028	HLP-VSL-00027A_HLP-VSL-00028
HLP-VSL-00027A	UFP-VSL-00001A	HLP-VSL-00027A_UFP-VSL-00001A
HLP-VSL-00027A	UFP-VSL-00001B	HLP-VSL-00027A_UFP-VSL-00001B
HLP-VSL-00028	PJM-RFD-VENT	HLP-VSL-00028_PJM-RFD-VENT
HLP-VSL-00028	HFP-VSL-00005	HLP-VSL-00028_HFP-VSL-00005
HLP-VSL-00028	HFP-VSL-00001	HLP-VSL-00028_HFP-VSL-00001
HLP14	HLP-VSL-00028	HLP14_HLP-VSL-00028
HLP14	HLP-VSL-00027B	HLP14_HLP-VSL-00027B
FRP-VSL-00002A	PJM-RFD-VENT	FRP-VSL-00002A_PJM-RFD-VENT
FRP-VSL-00002A	HLP-VSL-00022	FRP-VSL-00002A_HLP-VSL-00022
FRP-VSL-00002A	UFP-VSL-00001A	FRP-VSL-00002A_UFP-VSL-00001A
FRP-VSL-00002A	UFP-VSL-00001B	FRP-VSL-00002A_UFP-VSL-00001B
FRP-VSL-00002A	FEP-VSL-00017B	FRP-VSL-00002A_FEP-VSL-00017B
FRP-VSL-00002A	FEP-VSL-00017A	FRP-VSL-00002A_FEP-VSL-00017A
FRP-VSL-00002B	PJM-RFD-VENT	FRP-VSL-00002B_PJM-RFD-VENT
FRP-VSL-00002B	HLP-VSL-00022	FRP-VSL-00002B_HLP-VSL-00022
FRP-VSL-00002B	UFP-VSL-00001A	FRP-VSL-00002B_UFP-VSL-00001A
FRP-VSL-00002B	UFP-VSL-00001B	FRP-VSL-00002B_UFP-VSL-00001B

Upstream Equipment	Downstream Equipment	Totalizer File
FRP-VSL-00002B	FEP-VSL-00017B	FRP-VSL-00002B_FEP-VSL-00017B
FRP-VSL-00002B	FEP-VSL-00017A	FRP-VSL-00002B_FEP-VSL-00017A
FRP-VSL-00002D	PJM-RFD-VENT	FRP-VSL-00002D_PJM-RFD-VENT
FRP-VSL-00002D	HLP-VSL-00022	FRP-VSL-00002D_HLP-VSL-00022
FRP-VSL-00002D	UFP-VSL-00001A	FRP-VSL-00002D_UFP-VSL-00001A
FRP-VSL-00002D	UFP-VSL-00001B	FRP-VSL-00002D_UFP-VSL-00001B
FRP-VSL-00002D	FEP-VSL-00017B	FRP-VSL-00002D_FEP-VSL-00017B
FRP-VSL-00002D	FEP-VSL-00017A	FRP-VSL-00002D_FEP-VSL-00017A
FRP-VSL-00002C	PJM-RFD-VENT	FRP-VSL-00002C_PJM-RFD-VENT
FRP-VSL-00002C	HLP-VSL-00022	FRP-VSL-00002C_HLP-VSL-00022
FRP-VSL-00002C	UFP-VSL-00001A	FRP-VSL-00002C_UFP-VSL-00001A
FRP-VSL-00002C	UFP-VSL-00001B	FRP-VSL-00002C_UFP-VSL-00001B
FRP-VSL-00002C	FEP-VSL-00017B	FRP-VSL-00002C_FEP-VSL-00017B
FRP-VSL-00002C	FEP-VSL-00017A	FRP-VSL-00002C_FEP-VSL-00017A
TANK-FARM-LAW	FRP-VSL-00002D	TANK-FARM-LAW_FRP-VSL-00002D
TANK-FARM-LAW	FRP-VSL-00002C	TANK-FARM-LAW_FRP-VSL-00002C
TANK-FARM-LAW	FRP-VSL-00002B	TANK-FARM-LAW_FRP-VSL-00002B
TANK-FARM-LAW	FRP-VSL-00002A	TANK-FARM-LAW_FRP-VSL-00002A
HLP-VSL-00022	PJM-RFD-VENT	HLP-VSL-00022_PJM-RFD-VENT
HLP-VSL-00022	UFP-VSL-00001A	HLP-VSL-00022_UFP-VSL-00001A
HLP-VSL-00022	UFP-VSL-00001B	HLP-VSL-00022_UFP-VSL-00001B
TANK-FARM-HLW	HLP-VSL-00022	TANK-FARM-HLW_HLP-VSL-00022
CNP-VSL-00004	PJM-RFD-VENT	CNP-VSL-00004_PJM-RFD-VENT
CNP-VSL-00004	CXP-IXC-00004	CNP-VSL-00004_CXP-IXC-00004
CNP-VSL-00004	CXP-IXC-00003	CNP-VSL-00004_CXP-IXC-00003
CNP-VSL-00004	CXP-IXC-00002	CNP-VSL-00004_CXP-IXC-00002
CNP-VSL-00004	CXP-IXC-00001	CNP-VSL-00004_CXP-IXC-00001
CNP-VSL-00004	CNP-EVAP-00001	CNP-VSL-00004_CNP-EVAP-00001
CNP-EVAP-00001	CNP-VSL-00004	CNP-EVAP-00001_CNP-VSL-00004
CNP-EVAP-00001	PWD-VSL-00015	CNP-EVAP-00001_PWD-VSL-00015
CNP-EVAP-00001	PWD-VSL-00016	CNP-EVAP-00001_PWD-VSL-00016
CNP-EVAP-00001	HLP-VSL-00028	CNP-EVAP-00001_HLP-VSL-00028
CNP-EVAP-00001	HLP-VSL-00027B	CNP-EVAP-00001_HLP-VSL-00027B
CNP-EVAP-00001	CNP-VSL-00003	CNP-EVAP-00001_CNP-VSL-00003
NAR-TK-00006	CNP-VSL-00004	NAR-TK-00006_CNP-VSL-00004
CNP-VSL-00003	PJM-RFD-VENT	CNP-VSL-00003_PJM-RFD-VENT
CNP-VSL-00003	HLP-VSL-00028	CNP-VSL-00003_HLP-VSL-00028
CNP-VSL-00003	HLP-VSL-00027B	CNP-VSL-00003_HLP-VSL-00027B
NAR-TK-00005	CNP-EVAP-00001	NAR-TK-00005_CNP-EVAP-00001
PWD-VSL-00015	PJM-RFD-VENT	PWD-VSL-00015_PJM-RFD-VENT
PWD-VSL-00015	FEP-VSL-00017B	PWD-VSL-00015_FEP-VSL-00017B
PWD-VSL-00015	FEP-VSL-00017A	PWD-VSL-00015_FEP-VSL-00017A
PWD-VSL-00016	PJM-RFD-VENT	PWD-VSL-00016_PJM-RFD-VENT
PWD-VSL-00016	FEP-VSL-00017B	PWD-VSL-00016_FEP-VSL-00017B
PWD-VSL-00016	FEP-VSL-00017A	PWD-VSL-00016_FEP-VSL-00017A
PWD-VSL-00044	PWD-VSL-00016	PWD-VSL-00044_PWD-VSL-00016
PWD-VSL-00044	PJM-RFD-VENT	PWD-VSL-00044_PJM-RFD-VENT

Upstream Equipment	Downstream Equipment	Totalizer File
PWD-VSL-00044	FEP-VSL-00017B	PWD-VSL-00044_FEP-VSL-00017B
PWD-VSL-00044	FEP-VSL-00017A	PWD-VSL-00044_FEP-VSL-00017A
PWD-VSL-00043	PJM-RFD-VENT	PWD-VSL-00043_PJM-RFD-VENT
PWD-VSL-00043	PWD-VSL-00044	PWD-VSL-00043_PWD-VSL-00044
PWD-VSL-00033	PJM-RFD-VENT	PWD-VSL-00033_PJM-RFD-VENT
PWD-VSL-00033	PWD-VSL-00044	PWD-VSL-00033_PWD-VSL-00044
SHR-TK-00006	PWD-VSL-00015	SHR-TK-00006_PWD-VSL-00015
SHR-TK-00006	PWD-VSL-00016	SHR-TK-00006_PWD-VSL-00016
SHR-TK-00006	PWD-VSL-00044	SHR-TK-00006_PWD-VSL-00044
RLD-VSL-00007	PJV-HEPA-00004-5	RLD-VSL-00007_PJV-HEPA-00004-5
RLD-VSL-00007	PWD-VSL-00043	RLD-VSL-00007_PWD-VSL-00043
SHR-TK-00002	RLD-VSL-00007	SHR-TK-00002_RLD-VSL-00007
DIW-IXC-RINSE-1	CXP-IXC-00002	DIW-IXC-RINSE-1_CXP-IXC-00002
DIW-IXC-RINSE-2	CXP-IXC-00002	DIW-IXC-RINSE-2_CXP-IXC-00002
SHR-TK-00005	CXP-IXC-00002	SHR-TK-00005_CXP-IXC-00002
CXP-IXC-00002	CNP-EVAP-00001	CXP-IXC-00002_CNP-EVAP-00001
CXP-IXC-00002	RDP-VSL-00002A	CXP-IXC-00002_RDP-VSL-00002A
CXP-IXC-00002	RDP-VSL-00002B	CXP-IXC-00002_RDP-VSL-00002B
CXP-IXC-00002	UFP-VSL-00062A	CXP-IXC-00002_UFP-VSL-00062A
CXP-IXC-00002	CXP-VSL-00026A	CXP-IXC-00002_CXP-VSL-00026A
CXP-IXC-00002	CXP-VSL-00026C	CXP-IXC-00002_CXP-VSL-00026C
CXP-IXC-00002	CXP-VSL-00026B	CXP-IXC-00002_CXP-VSL-00026B
CXP-IXC-00002	CXP-IXC-00003	CXP-IXC-00002_CXP-IXC-00003
CXP-IXC-00002	PWD-VSL-00015	CXP-IXC-00002_PWD-VSL-00015
CXP-IXC-00002	PWD-VSL-00016	CXP-IXC-00002_PWD-VSL-00016
CXP-IXC-00002	CXP-IXC-00002	CXP-IXC-00002_CXP-IXC-00002
DIW-IXC-RINSE-1	CXP-IXC-00001	DIW-IXC-RINSE-1_CXP-IXC-00001
DIW-IXC-RINSE-2	CXP-IXC-00001	DIW-IXC-RINSE-2_CXP-IXC-00001
SHR-TK-00005	CXP-IXC-00001	SHR-TK-00005_CXP-IXC-00001
CXP-IXC-00001	CNP-EVAP-00001	CXP-IXC-00001_CNP-EVAP-00001
CXP-IXC-00001	RDP-VSL-00002A	CXP-IXC-00001_RDP-VSL-00002A
CXP-IXC-00001	RDP-VSL-00002B	CXP-IXC-00001_RDP-VSL-00002B
CXP-IXC-00001	UFP-VSL-00062A	CXP-IXC-00001_UFP-VSL-00062A
CXP-IXC-00001	CXP-VSL-00026A	CXP-IXC-00001_CXP-VSL-00026A
CXP-IXC-00001	CXP-VSL-00026C	CXP-IXC-00001_CXP-VSL-00026C
CXP-IXC-00001	CXP-VSL-00026B	CXP-IXC-00001_CXP-VSL-00026B
CXP-IXC-00001	CXP-IXC-00002	CXP-IXC-00001_CXP-IXC-00002
CXP-IXC-00001	PWD-VSL-00015	CXP-IXC-00001_PWD-VSL-00015
CXP-IXC-00001	PWD-VSL-00016	CXP-IXC-00001_PWD-VSL-00016
CXP-IXC-00001	CXP-IXC-00001	CXP-IXC-00001_CXP-IXC-00001
DIW-IXC-RINSE-1	CXP-IXC-00004	DIW-IXC-RINSE-1_CXP-IXC-00004
DIW-IXC-RINSE-2	CXP-IXC-00004	DIW-IXC-RINSE-2_CXP-IXC-00004
SHR-TK-00005	CXP-IXC-00004	SHR-TK-00005_CXP-IXC-00004
CXP-IXC-00004	CNP-EVAP-00001	CXP-IXC-00004_CNP-EVAP-00001
CXP-IXC-00004	RDP-VSL-00002A	CXP-IXC-00004_RDP-VSL-00002A
CXP-IXC-00004	RDP-VSL-00002B	CXP-IXC-00004_RDP-VSL-00002B
CXP-IXC-00004	UFP-VSL-00062A	CXP-IXC-00004_UFP-VSL-00062A

Upstream Equipment	Downstream Equipment	Totalizer File
CXP-IXC-00004	CXP-VSL-00026A	CXP-IXC-00004_CXP-VSL-00026A
CXP-IXC-00004	CXP-VSL-00026C	CXP-IXC-00004_CXP-VSL-00026C
CXP-IXC-00004	CXP-VSL-00026B	CXP-IXC-00004_CXP-VSL-00026B
CXP-IXC-00004	CXP-IXC-00001	CXP-IXC-00004_CXP-IXC-00001
CXP-IXC-00004	PWD-VSL-00015	CXP-IXC-00004_PWD-VSL-00015
CXP-IXC-00004	PWD-VSL-00016	CXP-IXC-00004_PWD-VSL-00016
CXP-IXC-00004	CXP-IXC-00004	CXP-IXC-00004_CXP-IXC-00004
DIW-IXC-RINSE-1	CXP-IXC-00003	DIW-IXC-RINSE-1_CXP-IXC-00003
DIW-IXC-RINSE-2	CXP-IXC-00003	DIW-IXC-RINSE-2_CXP-IXC-00003
SHR-TK-00005	CXP-IXC-00003	SHR-TK-00005_CXP-IXC-00003
CXP-IXC-00003	CNP-EVAP-00001	CXP-IXC-00003_CNP-EVAP-00001
CXP-IXC-00003	RDP-VSL-00002A	CXP-IXC-00003_RDP-VSL-00002A
CXP-IXC-00003	RDP-VSL-00002B	CXP-IXC-00003_RDP-VSL-00002B
CXP-IXC-00003	UFP-VSL-00062A	CXP-IXC-00003_UFP-VSL-00062A
CXP-IXC-00003	CXP-VSL-00026A	CXP-IXC-00003_CXP-VSL-00026A
CXP-IXC-00003	CXP-VSL-00026C	CXP-IXC-00003_CXP-VSL-00026C
CXP-IXC-00003	CXP-VSL-00026B	CXP-IXC-00003_CXP-VSL-00026B
CXP-IXC-00003	CXP-IXC-00004	CXP-IXC-00003_CXP-IXC-00004
CXP-IXC-00003	PWD-VSL-00015	CXP-IXC-00003_PWD-VSL-00015
CXP-IXC-00003	PWD-VSL-00016	CXP-IXC-00003_PWD-VSL-00016
CXP-IXC-00003	CXP-IXC-00003	CXP-IXC-00003_CXP-IXC-00003
CXP-VSL-00005	PJM-RFD-VENT	CXP-VSL-00005_PJM-RFD-VENT
CXP-VSL-00005	CXP-IXC-00001	CXP-VSL-00005_CXP-IXC-00001
CXP-VSL-00005	CXP-IXC-00002	CXP-VSL-00005_CXP-IXC-00002
CXP-VSL-00005	CXP-IXC-00003	CXP-VSL-00005_CXP-IXC-00003
CXP-VSL-00005	CXP-IXC-00004	CXP-VSL-00005_CXP-IXC-00004
SHR-TK-00005	CXP-VSL-00005	SHR-TK-00005_CXP-VSL-00005
IX-DI-WATER	UFP-VSL-00062A	IX-DI-WATER_UFP-VSL-00062A
SHR-TK-00001	CNP-EVAP-00001	SHR-TK-00001_CNP-EVAP-00001
CXP-FILT-00001	PWD-VSL-00016	CXP-FILT-00001_PWD-VSL-00016
CXP-FILT-00001	CXP-IXC-00004	CXP-FILT-00001_CXP-IXC-00004
CXP-FILT-00001	CXP-IXC-00003	CXP-FILT-00001_CXP-IXC-00003
CXP-FILT-00001	CXP-IXC-00002	CXP-FILT-00001_CXP-IXC-00002
CXP-FILT-00001	CXP-IXC-00001	CXP-FILT-00001_CXP-IXC-00001
SHR-TK-00005	CXP-FILT-00001	SHR-TK-00005_CXP-FILT-00001
PVP-HEME-00001	PVP-VSL-00001	PVP-HEME-00001_PVP-VSL-00001
PVP-HEME-00001	PVP-HEPA-00001-2	PVP-HEME-00001_PVP-HEPA-00001-2
PVP-VESSEL-VENT	PVP-SCB-00002	PVP-VESSEL-VENT_PVP-SCB-00002
PVP-VESSEL-VENT	PVP-VESSEL-VENT	PVP-VESSEL-VENT_PVP-VESSEL-VENT
PVP-OXID-00001	PVP-ABS-00001AB	PVP-OXID-00001_PVP-ABS-00001AB
PVP-OXID-00001	PVP-OXID-00001	PVP-OXID-00001_PVP-OXID-00001
PJM-RFD-VENT	PJV-VSL-00001	PJM-RFD-VENT_PJV-VSL-00001
PJM-RFD-VENT	PJM-RFD-VENT	PJM-RFD-VENT_PJM-RFD-VENT
PVP-ABS-00001AB	PVP-STACK	PVP-ABS-00001AB_PVP-STACK
PVP-ABS-00001AB	PVP-ABS-00001AB	PVP-ABS-00001AB_PVP-ABS-00001AB
PJV-VSL-00001	PWD-VSL-00043	PJV-VSL-00001_PWD-VSL-00043
PJV-VSL-00001	PJV-HEPA	PJV-VSL-00001_PJV-HEPA

Upstream Equipment	Downstream Equipment	Totalizer File
PVP-VSL-00001	PWD-VSL-00044	PVP-VSL-00001_PWD-VSL-00044
DIW-TK-00004	PVP-HEME-00001	DIW-TK-00004_PVP-HEME-00001
DIW-TK-00004	PJV-VSL-00001	DIW-TK-00004_PJV-VSL-00001
AIR-VENT-LUMP-SUM	PVP-VESSEL-VENT	AIR-VENT-LUMP-SUM_PVP-VESSEL-VENT
SHR-TK-00007	PVP-SCB-00002	SHR-TK-00007_PVP-SCB-00002
PVP-SCB-00002	PVP-HEME-00001	PVP-SCB-00002_PVP-HEME-00001
PVP-SCB-00002	PWD-VSL-00044	PVP-SCB-00002_PWD-VSL-00044
PVP-HEPA-00001-2	PVP-OXID-00001	PVP-HEPA-00001-2_PVP-OXID-00001
PVP-HEPA-00001-2	PVP-HEPA-00001-2	PVP-HEPA-00001-2_PVP-HEPA-00001-2
PJV-HEPA	PVP-STACK	PJV-HEPA_PVP-STACK
PJV-HEPA	PJV-HEPA	PJV-HEPA_PJV-HEPA
UFV-HLP-3HR-ROTATION	PVP-VESSEL-VENT	UFV-HLP-3HR-ROTATION_PVP-VESSEL-VENT
RLD-VSL-00004	RLD-VSL-00005	RLD-VSL-00004_RLD-VSL-00005
RLD-VSL-00005	TLP-VSL-00009A	RLD-VSL-00005_TLP-VSL-00009A
RLD-VSL-00005	TLP-VSL-00009B	RLD-VSL-00005_TLP-VSL-00009B
RLD-VSL-00005	SUPPLEMENTAL-LAW-RECYCLE	RLD-VSL-00005_SUPPLEMENTAL-LAW-RECYCLE
LVP-TK-00001	LVP-SCB-00001	LVP-TK-00001_LVP-SCB-00001
LVP-TK-00001	RLD-VSL-00017A	LVP-TK-00001_RLD-VSL-00017A
LVP-TK-00001	RLD-VSL-00017B	LVP-TK-00001_RLD-VSL-00017B
LVP-VSL-00001-NAOH	LVP-TK-00001	LVP-VSL-00001-NAOH_LVP-TK-00001
LVP-VSL-00001-WATER	LVP-TK-00001	LVP-VSL-00001-WATER_LVP-TK-00001
LMP-MLTR-00002-AIR	LMP-MLTR-00002	LMP-MLTR-00002-AIR_LMP-MLTR-00002
LOP-WESP-00002	RLD-VSL-00004	LOP-WESP-00002_RLD-VSL-00004
LOP-WESP-00002	LAW-VESSEL-VENT	LOP-WESP-00002_LAW-VESSEL-VENT
LOP09	LOP-WESP-00002	LOP09_LOP-WESP-00002
LOP-SCB-00002-WATER	LOP-SCB-00002	LOP-SCB-00002-WATER_LOP-SCB-00002
LOP-SCB-00002	RLD-VSL-00005	LOP-SCB-00002_RLD-VSL-00005
LOP-SCB-00002	LOP-WESP-00002	LOP-SCB-00002_LOP-WESP-00002
LMP-MLTR-00002-WATER	LMP-MLTR-00002	LMP-MLTR-00002-WATER_LMP-MLTR-00002
LMP-MLTR-00002	LOP-SCB-00002	LMP-MLTR-00002_LOP-SCB-00002
LMP-MLTR-00002	LAW-CONTAINERS-2	LMP-MLTR-00002_LAW-CONTAINERS-2
HFP-VSL-00002	HMP-MLTR-00001	HFP-VSL-00002_HMP-MLTR-00001
HFP-VSL-00001	HFP-VSL-00002	HFP-VSL-00001_HFP-VSL-00002
HFP-VSL-00006	HMP-MLTR-00002	HFP-VSL-00006_HMP-MLTR-00002
HFP-VSL-00005	HFP-VSL-00006	HFP-VSL-00005_HFP-VSL-00006
RHEOLOGY-HLW	HFP-VSL-00005	RHEOLOGY-HLW_HFP-VSL-00005
RHEOLOGY-HLW	HFP-VSL-00001	RHEOLOGY-HLW_HFP-VSL-00001
LVP-SCB-00001	LVP-TK-00001	LVP-SCB-00001_LVP-TK-00001
LVP-SCB-00001	LAW-STACK	LVP-SCB-00001_LAW-STACK
LVP-SCR-00001-2	LVP-SCB-00001	LVP-SCR-00001-2_LVP-SCB-00001
LVP-SCR-00001-2	LVP-SCR-00001-2	LVP-SCR-00001-2_LVP-SCR-00001-2
AMR-VSL-00001-2-NH3	LVP-SCR-00001-2	AMR-VSL-00001-2-NH3_LVP-SCR-00001-2
LAW-VESSEL-VENT-	LAW-VESSEL-VENT	LAW-VESSEL-VENT-AIR_LAW-VESSEL-VENT

Upstream Equipment	Downstream Equipment	Totalizer File
AIR		
LAW-VESSEL-VENT	LVP-HEPA-00001AB	LAW-VESSEL-VENT_LVP-HEPA-00001AB
LAW-VESSEL-VENT	LAW-VESSEL-VENT	LAW-VESSEL-VENT_LAW-VESSEL-VENT
LVP-ADBR-00001AB	LVP-SCR-00001-2	LVP-ADBR-00001AB_LVP-SCR-00001-2
LVP-ADBR-00001AB	LVP-ADBR-00001AB	LVP-ADBR-00001AB_LVP-ADBR-00001AB
AMR-VSL-00001-2-AIR	LVP-SCR-00001-2	AMR-VSL-00001-2-AIR_LVP-SCR-00001-2
LVP-HEPA-00001AB	LVP-ADBR-00001AB	LVP-HEPA-00001AB_LVP-ADBR-00001AB
LVP-HEPA-00001AB	LVP-HEPA-00001AB	LVP-HEPA-00001AB_LVP-HEPA-00001AB
LMP-MLTR-00001-AIR	LMP-MLTR-00001	LMP-MLTR-00001-AIR_LMP-MLTR-00001
LOP-WESP-00001	RLD-VSL-00004	LOP-WESP-00001_RLD-VSL-00004
LOP-WESP-00001	LAW-VESSEL-VENT	LOP-WESP-00001_LAW-VESSEL-VENT
LOP09	LOP-WESP-00001	LOP09_LOP-WESP-00001
LOP-SCB-00001-WATER	LOP-SCB-00001	LOP-SCB-00001-WATER_LOP-SCB-00001
LOP-SCB-00001	RLD-VSL-00005	LOP-SCB-00001_RLD-VSL-00005
LOP-SCB-00001	LOP-WESP-00001	LOP-SCB-00001_LOP-WESP-00001
LMP-MLTR-00001-WATER	LMP-MLTR-00001	LMP-MLTR-00001-WATER_LMP-MLTR-00001
LMP-MLTR-00001	LOP-SCB-00001	LMP-MLTR-00001_LOP-SCB-00001
LMP-MLTR-00001	LAW-CONTAINERS-1	LMP-MLTR-00001_LAW-CONTAINERS-1
HMP-MLTR-00001	HOP-SCB-00001	HMP-MLTR-00001_HOP-SCB-00001
HMP-MLTR-00001	HLW-CANISTERS-1	HMP-MLTR-00001_HLW-CANISTERS-1
HMP-MLTR-00001-AIR	HMP-MLTR-00001	HMP-MLTR-00001-AIR_HMP-MLTR-00001
HOP-WESP-00001	HOP-SCB-00001	HOP-WESP-00001_HOP-SCB-00001
HOP-WESP-00001	HLW-VESSEL-VENT-1	HOP-WESP-00001_HLW-VESSEL-VENT-1
DIW-TK-00002	HOP-WESP-00001	DIW-TK-00002_HOP-WESP-00001
HOP08-1	HOP-SCB-00001	HOP08-1_HOP-SCB-00001
HOP-SCB-00001	PJV-HEPA-00004-5	HOP-SCB-00001_PJV-HEPA-00004-5
HOP-SCB-00001	RLD-VSL-00007	HOP-SCB-00001_RLD-VSL-00007
HOP-SCB-00001	HOP-WESP-00001	HOP-SCB-00001_HOP-WESP-00001
HOP-HEME-00001	HOP-SCB-00001	HOP-HEME-00001_HOP-SCB-00001
HOP-HEME-00001	HOP-HEPA-00001-2-AB	HOP-HEME-00001_HOP-HEPA-00001-2-AB
DIW-TK-00002	HOP-HEME-00001	DIW-TK-00002_HOP-HEME-00001
HLW-VESSEL-VENT-1	HOP-HEME-00001	HLW-VESSEL-VENT-1_HOP-HEME-00001
HLW-VESSEL-VENT-1	HLW-VESSEL-VENT-1	HLW-VESSEL-VENT-1_HLW-VESSEL-VENT-1
HOP-SCR-00001	HLW-STACK	HOP-SCR-00001_HLW-STACK
HOP-SCR-00001	HOP-SCR-00001	HOP-SCR-00001_HOP-SCR-00001
HOP-ABS-00002	HOP-SCR-00001	HOP-ABS-00002_HOP-SCR-00001
HOP-ABS-00002	HOP-ABS-00002	HOP-ABS-00002_HOP-ABS-00002
HOP-SCR-00001-NH3	HOP-SCR-00001	HOP-SCR-00001-NH3_HOP-SCR-00001
HLW-VESSEL-VENT-1-AIR	HLW-VESSEL-VENT-1	HLW-VESSEL-VENT-1-AIR_HLW-VESSEL-VENT-1
HOP-ADBR-00001AB	HOP-ABS-00002	HOP-ADBR-00001AB_HOP-ABS-00002
HOP-ADBR-00001AB	HOP-ADBR-00001AB	HOP-ADBR-00001AB_HOP-ADBR-00001AB
HOP-SCR-00001-AIR	HOP-SCR-00001	HOP-SCR-00001-AIR_HOP-SCR-00001
HOP-HEPA-00001-2-AB	HOP-ADBR-00001AB	HOP-HEPA-00001-2-AB_HOP-ADBR-00001AB
HOP-HEPA-00001-2-AB	HOP-HEPA-00001-2-AB	HOP-HEPA-00001-2-AB_HOP-HEPA-00001-2-AB

Upstream Equipment	Downstream Equipment	Totalizer File
PJV-HEPA-00004-5	HLW-PJV-STACK	PJV-HEPA-00004-5_HLW-PJV-STACK
PJV-HEPA-00004-5	PJV-HEPA-00004-5	PJV-HEPA-00004-5_PJV-HEPA-00004-5
HMP-MLTR-00002	HOP-SCB-00002	HMP-MLTR-00002_HOP-SCB-00002
HMP-MLTR-00002	HLW-CANISTERS-2	HMP-MLTR-00002_HLW-CANISTERS-2
HMP-MLTR-00002-AIR	HMP-MLTR-00002	HMP-MLTR-00002-AIR_HMP-MLTR-00002
HOP-WESP-00002	HOP-SCB-00002	HOP-WESP-00002_HOP-SCB-00002
HOP-WESP-00002	HLW-VESSEL-VENT-2	HOP-WESP-00002_HLW-VESSEL-VENT-2
DIW-TK-00002	HOP-WESP-00002	DIW-TK-00002_HOP-WESP-00002
HOP08-2	HOP-SCB-00002	HOP08-2_HOP-SCB-00002
HOP-SCB-00002	PJV-HEPA-00004-5	HOP-SCB-00002_PJV-HEPA-00004-5
HOP-SCB-00002	RLD-VSL-00007	HOP-SCB-00002_RLD-VSL-00007
HOP-SCB-00002	HOP-WESP-00002	HOP-SCB-00002_HOP-WESP-00002
HOP-HEME-00002	HOP-SCB-00002	HOP-HEME-00002_HOP-SCB-00002
HOP-HEME-00002	HOP-HEPA-00007-8-AB	HOP-HEME-00002_HOP-HEPA-00007-8-AB
DIW-TK-00002	HOP-HEME-00002	DIW-TK-00002_HOP-HEME-00002
HLW-VESSEL-VENT-2	HOP-HEME-00002	HLW-VESSEL-VENT-2_HOP-HEME-00002
HLW-VESSEL-VENT-2	HLW-VESSEL-VENT-2	HLW-VESSEL-VENT-2_HLW-VESSEL-VENT-2
HOP-SCR-00002	HLW-STACK	HOP-SCR-00002_HLW-STACK
HOP-SCR-00002	HOP-SCR-00002	HOP-SCR-00002_HOP-SCR-00002
HOP-ABS-00003	HOP-SCR-00002	HOP-ABS-00003_HOP-SCR-00002
HOP-ABS-00003	HOP-ABS-00003	HOP-ABS-00003_HOP-ABS-00003
HLW-VESSEL-VENT-2-AIR	HLW-VESSEL-VENT-2	HLW-VESSEL-VENT-2-AIR_HLW-VESSEL-VENT-2
HOP-ADBR-00002AB	HOP-ABS-00003	HOP-ADBR-00002AB_HOP-ABS-00003
HOP-ADBR-00002AB	HOP-ADBR-00002AB	HOP-ADBR-00002AB_HOP-ADBR-00002AB
HOP-SCR-00002-NH3	HOP-SCR-00002	HOP-SCR-00002-NH3_HOP-SCR-00002
HOP-SCR-00002-AIR	HOP-SCR-00002	HOP-SCR-00002-AIR_HOP-SCR-00002
HOP-HEPA-00007-8-AB	HOP-ADBR-00002AB	HOP-HEPA-00007-8-AB_HOP-ADBR-00002AB
HOP-HEPA-00007-8-AB	HOP-HEPA-00007-8-AB	HOP-HEPA-00007-8-AB_HOP-HEPA-00007-8-AB
HDH-VSL-00001	HDH-VSL-00003	HDH-VSL-00001_HDH-VSL-00003
NAR-TK-00001	HDH-VSL-00002	NAR-TK-00001_HDH-VSL-00002
HDH-VSL-00002	HDH-VSL-00003	HDH-VSL-00002_HDH-VSL-00003
HDH-VSL-00001-WATER	HDH-VSL-00001	HDH-VSL-00001-WATER_HDH-VSL-00001
HDH-TK-00002	HDH-VSL-00002	HDH-TK-00002_HDH-VSL-00002
DIW-TK-00002	HDH-VSL-00002	DIW-TK-00002_HDH-VSL-00002
HDH-VSL-00003	RLD-VSL-00007	HDH-VSL-00003_RLD-VSL-00007
SHR-TK-00002	HDH-VSL-00003	SHR-TK-00002_HDH-VSL-00003
HPS	HDH-VSL-00003	HPS_HDH-VSL-00003
HDH-TK-00003	HDH-VSL-00003	HDH-TK-00003_HDH-VSL-00003
HDH-VSL-00004	HDH-VSL-00003	HDH-VSL-00004_HDH-VSL-00003
NAR-TK-00001	HDH-VSL-00004	NAR-TK-00001_HDH-VSL-00004
HDH-TK-00002	HDH-VSL-00004	HDH-TK-00002_HDH-VSL-00004
DIW-TK-00002	HDH-VSL-00004	DIW-TK-00002_HDH-VSL-00004
HDH-VSL-00003-FLUSH	RLD-VSL-00007	HDH-VSL-00003-FLUSH_RLD-VSL-00007
PSA	HLP-VSL-00028	PSA_HLP-VSL-00028
PSA	HLP-VSL-00027B	PSA_HLP-VSL-00027B

Upstream Equipment	Downstream Equipment	Totalizer File
PSA	HLP-VSL-00027A	PSA_HLP-VSL-00027A
PSA	UFP-VSL-00062B	PSA_UFP-VSL-00062B
PSA	UFP-VSL-00062C	PSA_UFP-VSL-00062C
PSA	UFP-VSL-00062A	PSA_UFP-VSL-00062A
PSA	UFP-VSL-00002B	PSA_UFP-VSL-00002B
PSA	UFP-VSL-00002A	PSA_UFP-VSL-00002A
PSA	UFP-VSL-00001A	PSA_UFP-VSL-00001A
PSA	UFP-VSL-00001B	PSA_UFP-VSL-00001B
PSA	RLD-VSL-00007	PSA_RLD-VSL-00007
PSA	RDP-VSL-00002C	PSA_RDP-VSL-00002C
PSA	RDP-VSL-00002A	PSA_RDP-VSL-00002A
PSA	RDP-VSL-00002B	PSA_RDP-VSL-00002B
PSA	PWD-VSL-00044	PSA_PWD-VSL-00044
PSA	PWD-VSL-00016	PSA_PWD-VSL-00016
PSA	PWD-VSL-00015	PSA_PWD-VSL-00015
PSA	PWD-VSL-00043	PSA_PWD-VSL-00043
PSA	PWD-VSL-00033	PSA_PWD-VSL-00033
PSA	HOP-SCB-00002	PSA_HOP-SCB-00002
PSA	HOP-SCB-00001	PSA_HOP-SCB-00001
PSA	FRP-VSL-00002D	PSA_FRP-VSL-00002D
PSA	FRP-VSL-00002C	PSA_FRP-VSL-00002C
PSA	FRP-VSL-00002B	PSA_FRP-VSL-00002B
PSA	FRP-VSL-00002A	PSA_FRP-VSL-00002A
PSA	HLP-VSL-00022	PSA_HLP-VSL-00022
PSA	FEP-VSL-00017A	PSA_FEP-VSL-00017A
PSA	FEP-VSL-00017B	PSA_FEP-VSL-00017B
PSA	CXP-VSL-00026C	PSA_CXP-VSL-00026C
PSA	TCP-VSL-00001	PSA_TCP-VSL-00001
PSA	CXP-VSL-00026B	PSA_CXP-VSL-00026B
PSA	CXP-VSL-00026A	PSA_CXP-VSL-00026A
PSA	TLP-VSL-00009B	PSA_TLP-VSL-00009B
PSA	TLP-VSL-00009A	PSA_TLP-VSL-00009A
PSA	CXP-VSL-00005	PSA_CXP-VSL-00005
PSA	CNP-VSL-00003	PSA_CNP-VSL-00003
PSA	CNP-VSL-00004	PSA_CNP-VSL-00004
RFD-AIR	HLP-VSL-00028	RFD-AIR_HLP-VSL-00028
RFD-AIR	HLP-VSL-00027B	RFD-AIR_HLP-VSL-00027B
RFD-AIR	HLP-VSL-00027A	RFD-AIR_HLP-VSL-00027A
RFD-AIR	UFP-VSL-00062B	RFD-AIR_UFP-VSL-00062B
RFD-AIR	UFP-VSL-00062C	RFD-AIR_UFP-VSL-00062C
RFD-AIR	UFP-VSL-00062A	RFD-AIR_UFP-VSL-00062A
RFD-AIR	UFP-VSL-00002B	RFD-AIR_UFP-VSL-00002B
RFD-AIR	UFP-VSL-00002A	RFD-AIR_UFP-VSL-00002A
RFD-AIR	UFP-VSL-00001A	RFD-AIR_UFP-VSL-00001A
RFD-AIR	UFP-VSL-00001B	RFD-AIR_UFP-VSL-00001B
RFD-AIR	RLD-VSL-00007	RFD-AIR_RLD-VSL-00007
RFD-AIR	RDP-VSL-00002C	RFD-AIR_RDP-VSL-00002C

Upstream Equipment	Downstream Equipment	Totalizer File
RFD-AIR	RDP-VSL-00002A	RFD-AIR_RDP-VSL-00002A
RFD-AIR	RDP-VSL-00002B	RFD-AIR_RDP-VSL-00002B
RFD-AIR	PWD-VSL-00044	RFD-AIR_PWD-VSL-00044
RFD-AIR	PWD-VSL-00016	RFD-AIR_PWD-VSL-00016
RFD-AIR	PWD-VSL-00015	RFD-AIR_PWD-VSL-00015
RFD-AIR	PWD-VSL-00043	RFD-AIR_PWD-VSL-00043
RFD-AIR	PWD-VSL-00033	RFD-AIR_PWD-VSL-00033
RFD-AIR	HOP-SCB-00002	RFD-AIR_HOP-SCB-00002
RFD-AIR	HOP-SCB-00001	RFD-AIR_HOP-SCB-00001
RFD-AIR	FRP-VSL-00002D	RFD-AIR_FRP-VSL-00002D
RFD-AIR	FRP-VSL-00002C	RFD-AIR_FRP-VSL-00002C
RFD-AIR	FRP-VSL-00002B	RFD-AIR_FRP-VSL-00002B
RFD-AIR	FRP-VSL-00002A	RFD-AIR_FRP-VSL-00002A
RFD-AIR	HLP-VSL-00022	RFD-AIR_HLP-VSL-00022
RFD-AIR	FEP-VSL-00017A	RFD-AIR_FEP-VSL-00017A
RFD-AIR	FEP-VSL-00017B	RFD-AIR_FEP-VSL-00017B
RFD-AIR	CXP-VSL-00026C	RFD-AIR_CXP-VSL-00026C
RFD-AIR	TCP-VSL-00001	RFD-AIR_TCP-VSL-00001
RFD-AIR	CXP-VSL-00026B	RFD-AIR_CXP-VSL-00026B
RFD-AIR	CXP-VSL-00026A	RFD-AIR_CXP-VSL-00026A
RFD-AIR	TLP-VSL-00009B	RFD-AIR_TLP-VSL-00009B
RFD-AIR	TLP-VSL-00009A	RFD-AIR_TLP-VSL-00009A
RFD-AIR	CXP-VSL-00005	RFD-AIR_CXP-VSL-00005
RFD-AIR	CNP-VSL-00003	RFD-AIR_CNP-VSL-00003
RFD-AIR	CNP-VSL-00004	RFD-AIR_CNP-VSL-00004
FEP-VSL-00017A	PJM-RFD-VENT	FEP-VSL-00017A_PJM-RFD-VENT
FEP-VSL-00017A	FEP-SEP-00001A	FEP-VSL-00017A_FEP-SEP-00001A
FEP-VSL-00017A	FEP-SEP-00001B	FEP-VSL-00017A_FEP-SEP-00001B
FEP-VSL-00017B	PJM-RFD-VENT	FEP-VSL-00017B_PJM-RFD-VENT
FEP-VSL-00017B	FEP-SEP-00001A	FEP-VSL-00017B_FEP-SEP-00001A
FEP-VSL-00017B	FEP-SEP-00001B	FEP-VSL-00017B_FEP-SEP-00001B
FEP-VSL-00005A	RLD-TK-00006A	FEP-VSL-00005A_RLD-TK-00006A
FEP-DMST-00001A-AIR	FEP-DMST-00001A	FEP-DMST-00001A-AIR_FEP-DMST-00001A
FEP-DMST-00001A	FEP-VSL-00005A	FEP-DMST-00001A_FEP-VSL-00005A
FEP-DMST-00001A	PVP-VESSEL-VENT	FEP-DMST-00001A_PVP-VESSEL-VENT
FEPA-INTER-AFTER-CONDENSER-WATER	FEP-VSL-00005A	FEPA-INTER-AFTER-CONDENSER-WATER_FEP-VSL-00005A
FEP-SEP-00001B	FEP-DMST-00001B	FEP-SEP-00001B_FEP-DMST-00001B
FEP-SEP-00001B	HLP-VSL-00027A	FEP-SEP-00001B_HLP-VSL-00027A
FEP-SEP-00001B	UFP-VSL-00001A	FEP-SEP-00001B_UFP-VSL-00001A
FEP-SEP-00001B	UFP-VSL-00001B	FEP-SEP-00001B_UFP-VSL-00001B
FEP-SEP-00001B	FRP-VSL-00002A	FEP-SEP-00001B_FRP-VSL-00002A
FEP-VSL-00005B	RLD-TK-00006A	FEP-VSL-00005B_RLD-TK-00006A
FEP-DMST-00001B-AIR	FEP-DMST-00001B	FEP-DMST-00001B-AIR_FEP-DMST-00001B
FEP-DMST-00001B	FEP-VSL-00005B	FEP-DMST-00001B_FEP-VSL-00005B
FEP-DMST-00001B	PVP-VESSEL-VENT	FEP-DMST-00001B_PVP-VESSEL-VENT
FEPB-INTER-AFTER-	FEP-VSL-00005B	FEPB-INTER-AFTER-CONDENSER-

Upstream Equipment	Downstream Equipment	Totalizer File
CONDENSER-WATER		WATER_FEP-VSL-00005B
FEP-SEP-00001A	FEP-DMST-00001A	FEP-SEP-00001A_FEP-DMST-00001A
FEP-SEP-00001A	HLP-VSL-00027A	FEP-SEP-00001A_HLP-VSL-00027A
FEP-SEP-00001A	UFP-VSL-00001A	FEP-SEP-00001A_UFP-VSL-00001A
FEP-SEP-00001A	UFP-VSL-00001B	FEP-SEP-00001A_UFP-VSL-00001B
FEP-SEP-00001A	FRP-VSL-00002A	FEP-SEP-00001A_FRP-VSL-00002A