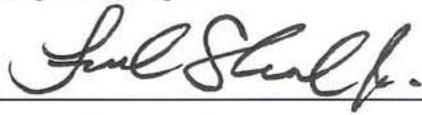


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SUMMARY OF CHANGES

Revision No.	Date	Description of Change
P-DB-J-00003: Enhanced Preliminary Design		
0	06/01/06	Issued for Enhanced Preliminary Design
1	09/25/07	Issued for DOE Approval
2	06/04/08	(Revised to Incorporate DCRs 0162, 0190, and 0247) Issued for DOE Approval
3	12/08/08	Issued for DOE Approval ((Revised per DMR-0516 to incorporate DCRs 0188, 0230, 0256 and 0262 and miscellaneous minor changes)
4	10/14/14	Issued for DOE Approval (Incorporate DCN-571, DCN-736, DCN-987, and DCN-1183).
5	02/26/16	Issued for DOE Approval (Incorporate DCN-1369).

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LIST OF ACRONYMS AND ABBREVIATIONS

μ	Micron
%	Percent
°F	Degrees Fahrenheit
ADS	Air Dilution System
AFDT	Alpha Finishing Drain Tank
AFF	Alpha Finishing Facility
AFP	Alpha Finishing Process
APA	Air Pulse Agitator
ASDT	Alpha Sorption Drain Tank
ASP	Alpha Strike Process
AST-A	Alpha Sorption Tank-A (in the Alpha Strike Process)
AST-B	Alpha Sorption Tank-B (in the Alpha Finishing Process)
Ba	Barium
CCA	Cold Chemicals Area
CDCSS	Cesium-depleted Clarified Salt Solution
CFF	Cross-flow Filter
CIP	Clean-in-place
CR	Control Room
Cs	Cesium
CSDT-A	Cleaning Solution Dump Tank-A
CSDT-B	Cleaning Solution Dump Tank-B
CSS	Clarified Salt Solution
CSSX	Caustic-side Solvent Extraction
DCS	Distributed Control System
Decon	Decontamination
DF	Decontamination Factor
DI	Deionized
DOE	U.S. Department of Energy
DOE-SR	U.S. Department of Energy-Savannah River
DSS	Decontaminated Salt Solution
DSSHT	Decontaminated Salt Solution Hold Tank
DW	Domestic Water
DWPF	Defense Waste Processing Facility
EPC	Engineering, Procurement, and Construction (Contractor)
FFT-A	Filter Feed Tank-A (in the Alpha Strike Process)
FFT-B	Filter Feed Tank-B (in the Alpha Finishing Process)
ft	Feet/Foot
ft/sec	Feet per second
g/L	grams per Liter
gpm	Gallons per minute
H ₂ C ₂ O ₄	Oxalic Acid
HEPA	High-Efficiency Particulate Air

LIST OF ACRONYMS AND ABBREVIATIONS (cont.)

HNO ₃	Nitric Acid
IST	Intermediate Storage Tank
K	Potassium
LFL	Lower Flammability Limit
LPPP	Low Point Pump Pit
LWO	Liquid Waste Operations
M	Molar
M&O	Management and Operating (Contractor)
mg/L	Milligrams per liter
Mgal/yr	Million gallons per year
MST	Monosodium Titanate
MSTT	MST/Sludge Transfer Tank
Na	Sodium
NaOH	Sodium Hydroxide
O:A	Organic to aqueous volumetric flow rate ratio
P&VG	Pump and Valve Gallery
PBVS	Process Building Ventilation System
PCHW	Process Chilled Water
PMVS	Pulse Mixer Ventilation System
PPT	Precipitate Pump Tank
psig	Pounds per square inch gauge
PVVS	Process Vessel Ventilation System
PW	Process Water
SDT	Solvent Drain Tank
SEHT	Strip Effluent Hold Tank
SHT	Solvent Hold Tank
SAST	Spent Acid Storage Tank
SPF	Saltstone Production Facility
Sr	Strontium
SFF	Saltstone Feed Facility
SSFT	Salt Solution Feed Tank
SSRT	Sludge Solids Receipt Tank
SWPF	Salt Waste Processing Facility
TK	Tank
VFD	Variable Frequency Drive
WAC	Waste Acceptance Criteria
wt%	Weight Percent
WTE	Waste Transfer Enclosure
WWHT	Wash Water Hold Tank

1.0 PURPOSE AND SCOPE

This document describes the design basis for process systems in the Salt Waste Processing Facility (SWPF). All other aspects of the design are described in P-DB-J-00004 (*SWPF Balance of Plant Basis of Design*¹). The SWPF Process Basis of Design, in conjunction with P-DB-J-00004, is intended to meet, in part, the requirements of Standard 3, Section (b)(2) of the Contract between the Engineering, Procurement, and Construction (EPC) Contractor and the U.S. Department of Energy (DOE) (DE-AC09-02SR22210: *Design, Construction, and Commissioning of a Salt Waste Processing Facility [SWPF]*²).

2.0 PLANT CAPACITY AND THROUGHPUT

2.1 Historical Perspective

Upon completion of Conceptual Design for the baseline 1.0 million gallon per year (Mgal/yr) facility, the U.S. Department of Energy-Savannah River (DOE-SR) directed both SWPF EPC Contractors to complete Conceptual Designs for the SWPF, based on a nominal capacity of 3.0 Mgal/yr (DE-03-036: "Salt Waste Processing Facility [SWPF] Project, Re-evaluation of Optimum Scale Selection for Phase 1B Conceptual Design"³). The SWPF availability and Defense Waste Processing Facility (DWPF) outage schedule assumptions were specified for design capacity calculations for the SWPF by DOE-SR (P-SWPF-03-1517: "Assumptions for SWPF Availability and DWPF Outages"⁴). Under these assumptions, the SWPF was to operate with an availability of 75 percent (%) and would be required to shut down for 6 months every 30 months for scheduled outages at DWPF. An allowance was also provided to take credit for the SWPF product storage volumes in the SWPF design capacity calculations. In order to meet the required nominal throughput, given these assumptions, the instantaneous throughput for the SWPF was required to be ≥ 4.95 Mgal/yr. DOE and the EPC critically reviewed the Actinide Removal Process and Caustic-side Solvent Extraction (CSSX) Process Conceptual Design in view of results from Monosodium Titanate (MST) and filtration performance tests completed after Conceptual Design and 719004/1 (*Parsons Preliminary Test Report: Caustic-side Solvent Extraction [CSSX] Pilot-scale Test [PST]*⁵). Changes to key design assumptions and the addition of an Alpha Finishing Process (AFP) resulted in a significant increase in predicted plant throughput capability. This improved design was the SWPF Enhanced Conceptual Design.

2.2 Current Design

The minimum throughput required by the SWPF Contract (DE-AC09-02SR22210²) is 3.75 Mgal/yr, based on an availability of 75% and an instantaneous throughput of 5.0 Mgal/yr. The current plant design baseline provides the ability to process batches of waste feed of 23,200 gallons each in approximately 21.6 hours. This results in an instantaneous maximum capacity of 9.4 Mgal/yr. A second MST strike process (referred to as the AFP) was also added downstream of the CSSX process. This provides the capability to maintain the same plant capacity when processing high-Strontium (Sr)/actinide batches that require two MST strikes.

The SWPF design throughput is set by the most limiting process operation (i.e., Alpha Strike Process [ASP], CSSX, or AFP). The tank, filter, and pump sizes for both the ASP and AFP are

sized to achieve an equivalent design throughput of 9.4 Mgal/yr. Although the rated capacity of the contactors used in the CSSX process also provides an equivalent waste feed processing rate of 9.4 Mgal/yr, operational experience with similar, but lower-capacity, contactors during the CSSX Pilot Test (719004/1⁵) indicated that CSSX performance, in terms of stage efficiency and solvent losses, was satisfactory up to approximately 80% of rated flow. Testing with a single full-scale contactor (P-RPT-J-00003: *SWPF Test Report: Solvent Carryover Characterization and Recovery Test*⁶) and the CSSX Full-scale Test (P-RPT-J-00009: *SWPF Test Report: Caustic-Side Solvent Extraction Full-Scale Test*⁷) showed a similar inability to reach rated flow with satisfactory operating conditions. Additional full-scale multi-contactor testing was completed to investigate improvements to the actual hydraulic throughput of the contactors. This testing showed that full hydraulic throughput through the contactors will likely be achieved. During Cold Commissioning the hydraulic throughput of the contactors installed in the facility will be tested during systemization of the contactors.

Nominal throughput for the SWPF is defined as the minimum sustained average throughput that can be expected over the life of the plant, after accounting for SWPF unavailability due to forced shutdowns or scheduled outages (availability). Assuming a minimum availability of 75%, the nominal throughput for the SWPF is:

$$\text{Nominal Throughput} = \text{Design Throughput} \times \text{SWPF Availability}$$

$$\text{Nominal Throughput} = 9.4 \text{ Mgal/yr} \times 0.75 = 7.0 \text{ Mgal/yr.}$$

This exceeds the SWPF Contract (DE-AC09-02SR22210²) requirement of 3.75 Mgal/yr. The actual facility throughput will also be affected by interfacing facilities (primarily H-Area Tank Farm, DWPF, and Saltstone Production Facility [SPF]). However, managing these interfaces falls under the auspices of the Liquid Waste Operations (LWO) Contractor and Site Management and Operating (M&O) Contractor, in cooperation with the EPC and direction from DOE.

3.0 PROCESS DESIGN

The SWPF treats salt waste in three successive basic unit operations: ASP, CSSX, and AFP (see Figure 3-1). These processes separate the radioactive elements (primarily actinides, Sr, and cesium [Cs]) from the bulk salt waste and concentrate them into a relatively small volume. This small volume is then transferred to the DWPF for vitrification. The remaining bulk salt waste contains only low levels of radioactive materials and is sent to the SPF for incorporation into grout. The ASP occurs first and is used to separate Sr/actinides from the waste feed by MST adsorption and filtration. The CSSX process follows the ASP and is used to remove Cs from the ASP filtrate by solvent extraction. The AFP is a process step that mimics the ASP and is used as necessary for additional Sr/actinide removal downstream of the CSSX process.

The ASP is operated as a batch process. Each batch of salt waste received in the SWPF is chemically adjusted and MST is added. The tank contents are mixed to allow the MST to adsorb the Sr and actinides (12 hours for a single strike and 6 hours each for multiple strikes). The resulting MST slurry is filtered to produce a (1) concentrated MST/sludge slurry and (2) clarified salt solution (CSS) filtrate. The concentrated MST/sludge slurry is washed to reduce the sodium (Na) concentration and transferred to DWPF, while the CSS is routed to the CSSX process.

The second SWPF processing stage is CSSX, which is a continuous flow process utilizing 36 contactor stages for extraction, scrubbing, stripping, and washing of aqueous and organic streams. The Cs is removed by contacting the CSS (aqueous phase) with an engineered solvent (organic phase) in the extraction stage contactors. The Cs-depleted aqueous outlet stream is sent to the AFP for sampling and analysis prior to transfer to the SPF or for another Sr/actinide removal operation. Following extraction, the Cs-enriched solvent is scrubbed to remove impurities (primarily Na and potassium [K]). The solvent is then contacted with a dilute nitric acid (HNO₃) strip solution in the stripping stages, where the Cs is transferred to the aqueous strip effluent. The strip effluent (containing a high concentration of Cs) is sent to DWPF for vitrification.

If the Sr/actinide concentration in the CSS sent to the CSSX process is sufficiently low, the aqueous raffinate from the extraction stages (decontaminated salt solution [DSS]) is sent to the Saltstone Facility to be solidified with a cementitious grout mixture. If the Sr/actinide concentration in the CSS is too high, the aqueous raffinate from the extraction stages (referred to as Cs-depleted CSS [CDCSS]) is sent to the AFP for a second MST strike.

The AFP, which is located downstream of the CSSX process, is the third SWPF processing stage. When the SWPF is operated in single-strike mode, DSS from the CSSX process is sent to the AFP for confirmatory sampling and staging prior to transfer to the SPF. If the Sr/actinide content of the waste feed is sufficiently high that a single MST strike cannot reduce the concentrations low enough for the CDCSS to meet the Saltstone Waste Acceptance Criteria (WAC) limits, the CDCSS will be sent to the AFP to undergo a second MST strike. Because the CDCSS contains a reduced concentration of Cs, the process equipment located in the Alpha Finishing Facility (AFF) can be operated and maintained without the extensive shielding and remote handling provisions required in the ASP.

3.1 Design Basis for Alpha Strike Process

This section identifies key process design parameters and discusses process operations involved in the ASP. Descriptions of the equipment required to perform these operations are provided, along with information on the tank/equipment sizing basis, where appropriate. All volumes/flow rates are approximate and indicative of normal operations, as defined in P-ESR-J-00001 (*SWPF Mass Balance Model Summary Description*⁸) for double MST strike mode, unless otherwise specified.

3.1.1 Waste Transfer

At the Tank Farm, waste removed from individual liquid radioactive waste tanks will be staged as macro-batches in Tank 49. A macro-batch will be subdivided into mini-batches for transfer and treatment in the SWPF. The macro-batch will provide a large volume of consistent composition waste to facilitate reproducibility and optimization of operations in the SWPF. Each macro-batch will be blended, mixed, and sampled. If the macro-batch sample results meet SWPF feed specifications, the macro-batch can be qualified for transfer to the SWPF. The Tank Farm waste feed preparation operations, including transfer between tanks, chemical adjustments, blending and mixing, and sampling and analysis, will be performed by the Site LWO and M&O.

The feed in Tank 49 will be required to conform to the SWPF Feed WAC prior to transfer to the SWPF. Sample results from source tanks may be used in the waste feed evaluation to qualify a macro-batch in Tank 49. Feed transfer to the SWPF will be performed in accordance with a transfer procedure, as specified in V-ESR-J-00010 (*SWPF Waste Transfer Interface Control Document [ICD-10]*⁹) and approved waste transfer operating procedures for the H-Area Tank Farm, S-Area DWPF, and J-Area SWPF.

Some macro-batches are expected to contain high Sr/actinide concentrations and will require multiple MST strikes. Because transfer of a new batch of waste from the source tanks to Tank 49 may take several days (during which time two or more SWPF feed batches may be processed), there will be a point in time during a macro-batch transfer at which Tank 49 Sr/actinide concentration will change enough to require a transition in SWPF operations from single-strike to multi-strike or from multi-strike to single-strike operation. In order to identify when this transition should be made, Tank 49, the SWPF Alpha Sorption Tank-A (AST-A), or the SWPF Salt Solution Feed Tank (SSFT) will be sampled periodically.

The SWPF feed will be transferred from Tank 49, as shown in V-ESR-J-00010⁹. Feed will be transferred to the SWPF at a nominal flow rate of 130 gallons per minute (gpm) and temperature of 77 ± 10 degrees Fahrenheit ($^{\circ}\text{F}$) (see V-ESR-J-00010). Feed will be received at the SWPF in mini-batch (referred to as a “batch” throughout the remainder of this section) transfers of approximately 23,200 gallons each. This is the batch size necessary to meet the design throughput requirements, given an overall AST-A cycle time of approximately 21.6 hours for single-strike operation. AST-A, Filter Feed Tank-A (FFT-A), and the Alpha Sorption Filters (FLT-102A/B/C) have been sized based on this cycle time and batch volume.

3.1.2 Alpha Sorption

3.1.2.1 Feed Receipt and Chemical Addition

Waste transfers are received in AST-A. AST-A serves as a mixing vessel for chemical adjustment of the feed and for adsorption of the Sr and actinides in the waste solution by the MST. P-ESR-J-00001⁸ defines the average AST-A batch size at 28,258 gallons, based on:

- Receipt of one feed batch (23,200 gallons);
- Addition of wash water (980 gallons), dilute caustic (3,602 gallons), and drains collected in the Alpha Sorption Drain Tank (ASDT) and Spent Acid Storage Tank (SAST) (405 gallons) to adjust the Na concentration from 6.44 Molar (M) Na to 5.6M Na; and
- Addition of MST (added to achieve 0.4 grams per liter [g/L] of MST) (71 gallons).

AST-A is sized with a working volume of 28,700 gallons to accommodate a single batch.^A Total tank capacity (volume to overflow) is the working volume combined with a freeboard allowance.

^A The tank working volume exceeds the required working volume because tank sizing is based on the greater of the values calculated by the Mass Balance Model or P-ESR-J-00003 (*SWPF Operations Assessment and Tank Utilization Models*). That Report models SWPF processes and evaluates tank sizing requirements.

Freeboard accommodates instrument uncertainties, batch size variations, level variations caused by agitator operation, operator response time to system upsets, and other effects. All process and support tanks are sized with a freeboard allowance, typically between 10 and 20 % of the tank capacity.

The waste feed received in AST-A is chemically adjusted from 6.44M to 5.6M Na by adding drains collected in the ASDT and SAST, recovered wash water from the Wash Water Hold Tank (WWHT), and/or 1.66M sodium hydroxide (NaOH) from the Caustic Dilution Feed Tank. The dilution source would depend on the quantity and composition of liquid available from each tank. Caustic is used for dilution rather than water to avoid precipitation of aluminosilicates (HLW-PRE-2002-0019: *Alpha Removal/Caustic Side Solvent Extraction Material Balance Calculations with Monosodium Titanate and Sodium Permanganate Alternative*¹⁰). MST solution is added to AST-A to achieve a final MST concentration of 0.4 g/L. The MST addition line is flushed with dilute caustic after MST has been added to AST-A.

AST-A is agitated to mix the tank contents and maintain the MST and sludge solids in suspension. Air Pulse Agitators (APAs) are used to agitate AST-A, as well as other vessels in the process cells including FFT-A, Sludge Solids Receipt Tank (SSRT), SSFT, and WWHT. APAs use compressed air to force fluid out of pots that are submerged in the tank. The rapid discharge of the pulse pot liquid column, and subsequent venting and refill of the pulse pot, create sufficient movement of the tank contents to keep solids in suspension and circulate the mixture.

The pulse pots are vented to the Pulse Mixer Ventilation System (PMVS). To increase the pulse pot rate of refill and available refill volume at low levels, the pulse pot vent header is maintained at a negative pressure. The PMVS exhaust fans draw air from the pulse pot vent header through one of two High-Efficiency Particulate Air (HEPA) filter trains. The PMVS exhaust air is discharged out the Exhaust Stack.

Each APA system is designed to operate at all conditions from the tank high level to the tank low level set points. APAs require no moving parts in the Process Vessel Cells, thereby eliminating the need for remote in-cell equipment removal or replacement.

AST-A is cooled by Process Chilled Water (PCHW) circulated through the tank jacket. AST-A is controlled at 77°F to promote adsorption by the MST (see CBU-SPT-2004-00153: "Engineering Position on the Need for Temperature Control in the MST Strike Tanks at 241-96H"¹¹).

3.1.2.2 Strontium and Actinide Adsorption

The MST added to AST-A selectively adsorbs soluble Sr and actinides present in the waste solution. Most of the Sr/actinide adsorption occurs rapidly after MST addition. In order to maximize the MST adsorption for one MST strike, the mixing/contact duration within AST-A is 12 hours. Decontamination Factors (DFs) used in P-ESR-J-00001⁸ are provided in Table 3-1 for both single- and multi-strike operation.

Table 3-1. Mass Balance Model Decontamination Factors

Radionuclide	Single-Strike (12-hour DF Values)	Multi-Strike	
		First-Strike (6-hour DF Values)	Subsequent-Strike (6-hour DF Values)
Uranium	1.35	1.3	1.3
Plutonium	5.5	4.7	3.9
Sr*	20	17	17
Americium**	4.6	3.4	1.5
Curium***	1	1	1
Neptunium	2.4	2.14	1.13

* Per guidance from SRT-LWP-2004-00076 (*Decontamination Factors for Strontium, Plutonium, Neptunium, and Uranium upon Contact of Concentrated Alkaline Waste Solutions with Monosodium Titanate*¹²) and WSRC-TR-2004-00145 (*Monosodium Titanate Multi-Strike Testing*¹³)

** Value from simulant testing. All other values are from real waste testing.

*** Curium: No data available for 6-hour or 12-hour strike operation.

The design value for solids in waste feed received in AST-A is 600 milligrams per liter (mg/L) (see PE-03-166: "Monosodium Titanate [MST] Performance in Removing Actinides/Sr from Feed at the Salt Waste Processing Facility [SWPF]"¹⁴). After the waste feed is chemically adjusted and sufficient time has been allowed for MST adsorption, the AST-A slurry is transferred to FFT-A, using one of the two AST-A Transfer Pumps (P-101A/B). These are low-shear centrifugal pumps with a design capacity of 300 gpm.

3.1.2.3 Alpha Sorption Cycle Times

The time taken to process a single AST-A batch is estimated to be approximately 21.6 hours, including waste feed and chemical addition times, MST adsorption time, and AST-A to FFT-A transfer time. Table 3-2 shows the duration for each process step in the AST-A cycle. Although the table shows each chemical adjustment step being performed separately, some steps may be performed concurrently or in an alternate sequence. The chemical adjustment process will be optimized during Commissioning. For design purposes, the chemical addition steps are conservatively assumed to occur in series.

Table 3-2. Alpha Sorption Tank-A Cycle Time – Single Monosodium Titanate Strike

Operational Step	Volume ¹ (gallons)	Flow Rate (gpm)	Time ¹ (hours)
Feed Delivery	23,200	130	2.97
MST Addition	71	5	0.24
Caustic Adjustment ²	4,987	100	0.83
Mix/Reaction	N/A	N/A	12
Operation Verification	N/A	N/A	2
Contingency ³	N/A	N/A	2
Transfer from AST-A	28,258	300	1.57
Line Flush ⁴	100	100	0.02
Total Cycle Time			21.63
Notes:			
1. Volumes and times are based on MST concentration of 0.4 g/L in AST-A.			
2. Total caustic adjustment volume based on Mass Balance Model quantities from Caustic Dilution Feed Tank, WWHT, ASDT, and SAST. These addition volumes will vary during normal operations, based on available quantities and compositions in these three tanks.			
3. Contingency allowance is for unanticipated delays.			
4. Line flush approximated.			

The AST-A cycle time for multi-strike operations is different from that for the single-strike operation described above. For two MST strikes, the MST adsorption time decreases by six hours. This results in a total cycle time for AST-A of 15.6 hours (6 hours less than that for single-strike operations).

When the SWPF is operated in single-strike mode, sampling and analysis are performed in either the Intermediate Storage Tank (IST) or Alpha Sorption Tank-B (AST-B) to verify that the waste meets SPF WAC limits.

3.1.3 Alpha Strike Filtration Process

The SWPF uses cross-flow filtration to concentrate the MST/slurry in FFT-A to approximately 5 weight percent (wt%). Two filtration circuits, each designed for 50% of the required capacity, are normally in service, with a third isolated and maintained in standby.

A two-pump system is employed for each Alpha Sorption filter circuit. This two-pump system consists of a feed pump and a recirculation pump. The Filter Feed/Solids Transfer Pumps (P-102-1A/B/C) provide positive pressure to the suction of the associated Filter Recirculation Pump (P-102-2A/B/C). Cross-flow through the Alpha Sorption Filters (FLT-102A/B/C) is provided by the Filter Recirculation Pumps. P-102-2A/B/C are designed to maintain a high flow

velocity (9-13 feet per second [ft/sec] nominally) through the cross-flow filter (CFF) tubes. Most of the slurry exiting the CFF is recirculated back to the recirculation pump suction. A bleed-back flow, equal to the Feed/Solids Transfer Pump feed flow rate minus the filtrate flow rate, is returned to FFT-A. The bleed-back flow is required to prevent excessive concentration of solids in the filter loop.

The CFFs contain parallel one-half-inch-diameter tubes fabricated from sintered stainless steel with a pore size of 0.1 micron (μ). The filters are sized such that two filters operating in parallel can produce filtrate at the design filtrate flow rate of 21.5 gpm, assuming an average filtrate flux rate of 0.06 gpm per square foot (WSRC-TR-2002-0134: *Filtration of Actual Savannah River Waste Treated with Permanganate or Monosodium Titanate*¹⁵). This filtration rate corresponds to a filtration cycle time of approximately 21.6 hours, which matches the AST cycle time and corresponds to a design processing rate of 9.4 Mgal/yr.

The Alpha Sorption Filters (FLT-102A/B/C) are designed so the filter tube bundle is self-draining and vertically removable. Each filter incorporates a back-pulse tank used for back-pulsing of the filter media. The back-pulse tanks are connected to the shell side of each filter. Compressed air at up to approximately 100 pounds per square inch gauge (psig) will be used to provide the motive pressure for back-pulsing or back-flushing of the filters. Each back-pulse tank will be equipped with a relief device located in a shielded enclosure to prevent over-pressurization of the filter shell and back-pulse tanks. The relief discharge will be vented back to the FFT-A vapor space. The Filter Feed/Solids Transfer Pumps (P102-1A/B/C) and Filter Recirculation Pumps (P-102-2A/B/C) are selected to minimize shear on the MST/sludge. The filter loop piping arrangements are designed so that concentrated sludge can gravity-drain back into FFT-A or to the ASDT at the conclusion of the filtration operation.

The FFT-A filtration circuits are designed to process one batch from AST-A, using two filter circuits within the same cycle time as AST-A. FFT-A is sized to allow the accumulation of seven batches (six concentrated batch volumes plus the batch volume from AST-A) prior to transfer to the SSRT to approximately match the batch receipt cycle times at DWPF. Each batch is filtered until the FFT-A level has been reduced to a predetermined minimum value equivalent to approximately 2,800 gallons. This minimum value has been established to allow effective mixing at low levels during transfer and filling of the subsequent batches. FFT-A has a working volume of 31,300 gallons to accommodate a batch transfer from AST-A and the previous concentrated batch volumes. FFT-A is equipped with an APA system to mix the tank and maintain solids in suspension. The transfer line from AST-A is flushed between batches with wash water from the WWHT.

After addition of the final (seventh) batch, the tank contents can be sampled to verify the final dewatering endpoint. Tank level indication, combined with the total measured quantity of filtrate removed, will be used to determine when the target is reached. The combined batches are normally filtered to 5 wt%. The concentrated sludge is then transferred to the SSRT by one of the three Filter Feed/Solids Transfer Pumps (P102-1A/B/C). When spent oxalic acid ($H_2C_2O_4$) is present in the SAST, the solids concentration endpoint in FFT-A will be adjusted upward to allow transfer of the material in the SAST to achieve 5 wt% in the SSRT after the SAST addition. Practical limitations are set on the extent of the additional dewatering in FFT-A and

the quantity of the SAST liquid transfer to maintain a minimum level in FFT-A and prevent over-concentration.

A cooling jacket around the external wall of FFT-A and heat exchangers installed in each filter recirculation loop remove pumping energy and decay heat. PCHW is supplied to the jacket and loop coolers, as required, to control the temperature of the slurry to 73°F, which minimizes the potential for solids precipitation downstream of the filters.

When processing waste feed with an entrained solids concentration of 600 mg/L, the volume of the concentrated sludge for each batch at 5 wt% will be approximately 400 gallons. The combined volume of 7 batches transferred to the SSRT will be approximately 2,800 gallons. The filtrate (CSS) flows to the SSFT for processing in the CSSX section. The capability is provided to recycle filtrate from the Alpha Sorption Filters to AST-A, if more than two MST strikes are required.

The filtrate production rate will vary as filtration progresses. It is anticipated that the filtrate flux rate will be high initially, but will decrease as the sludge approaches its target concentration. Filtrate flow control valves are provided to regulate the filtrate flow rate. The filtrate flow line will be equipped with redundant turbidity instruments to provide indication of filter breakthrough. On indication of filter breakthrough, a valve on the outlet of the filter will recycle flow to FFT-A. Additional redundant turbidity meters are installed downstream of the Salt Solution Feed Pumps (P-109 A/B). On indication of high solids in these meters, flow to the centrifugal contactors is stopped.

3.1.4 Clarified Salt Solution Storage

The primary function of the SSFT is to provide hold and surge volume between the ASP and CSSX Systems. The maximum working volume of the SSFT is 41,400 gallons. The SSFT is normally maintained at an intermediate level to provide storage volume for CSS from the ASP section if the CSSX is shut down, or feed for the CSSX section if the ASP section is shut down.

The normal operating volume for the SSFT is 20,700 gallons. This volume allows the CSSX System to operate at full capacity for up to 16 hours with no CSS production (ASP shut down). This value would also allow the ASP to operate for up to 16 hours with the CSSX process shut down. A 16-hour surge capacity corresponds to the average estimated time required to replace a contactor, as provided in P-ESR-J-00003, *SWPF Operations Assessment and Tank Utilization Models*¹⁶. Recycle capability is provided to return the SSFT contents to either AST-A or FFT-A.

3.1.5 Sludge Washing

During normal operation, the MST/sludge resulting from the concentration of seven batches in FFT-A is transferred to the SSRT for washing with Process Water (PW). The tank is designed with a narrow lower section and a wide upper section. This design is to allow effective mixing while providing sufficient vapor space to prevent approach to the tank Lower Flammability Limit (LFL) following a loss of agitation. The SSRT is equipped with an APA system to ensure that tank contents are mixed well and to maintain solids in suspension.

When processing waste feed with 600 mg/L of entrained solids that has been subjected to one MST strike, the combined volume of 7 concentrated batches from FFT-A will be approximately 2,800 gallons. The sludge is washed with PW to reduce the Na concentration from 5.6M to 0.5M. For this reduction in Na, approximately 2.4 gallons of PW will be used to wash 1 gallon of MST/sludge. During the wash cycle, PW is added continuously while the SSRT contents are recirculated through the Washing Filter (FLT-104).

The Washing Filter circuit uses a two-pump system similar to the Alpha Sorption Filter Systems. The Washing Filter Feed/Sludge Solids Transfer Pump (P-104-1) feeds the filter loop at 150 gpm. The Washing Filter Recirculation Pump (P-104-2) is a high-flow pump capable of maintaining a high flow velocity (nominally 9 to 13 ft/sec) through the Washing Filter (FLT-104) tubes. The filter outlet is recycled back to the recirculation pump suction. The Washing Filter is of the same design as the Alpha Sorption Filters (FLT-102A/B/C).

The filtrate is collected in the WWHT. During washing operations, the quantities of PW added and the filtrate produced are monitored. When the required quantity of water has been added and a corresponding quantity of filtrate removed, the washing operation is stopped. Contents of the SSRT are then sampled for Na concentration and other WAC parameters, as necessary.

The concentrated MST/sludge produced by Filter Feed Tank-B (FFT-B) in the AFP filtration operations (see Sections 3.3.3 and 3.3.4) will also be transferred to the SSRT for washing prior to transfer to DWPF. The estimated volume of MST/sludge produced from each FFT-B batch is approximately 190 gallons at 5 wt% solids. The combined MST/sludge volume (from both the ASP and the AFP) produced by processing 7 batches of waste feed through two MST strikes is, therefore, approximately 4,130 gallons at 5 wt%.

The washed sludge in the SSRT is pumped to the Precipitate Pump Tank (PPT) located in the Low Point Pump Pit (LPPP) by the Washing Filter Feed/Sludge Solids Transfer Pump (P-104-1) (see Section 3.5). This pump is a variable-speed centrifugal pump. The transfer rate to the PPT will be limited to approximately 150 gpm.

The SSRT has a working volume of 5,200 gallons to accommodate the combined volume of 7 concentrated batches from both FFT-A and FFT-B and approximately 500 gallons of line flush. After transfers from FFT-A or the MST/Sludge Transfer Tank (MSTT) to the SSRT, lines are flushed to remove residual solids using wash water from the WWHT or DSS from the DSS Hold Tank (DSSHT), respectively. The SSRT is equipped with a cooling jacket installed primarily to remove pumping and mixing energy.

3.1.6 Monosodium Titanate/Sludge Storage

The SSRT contents will be transferred to the DWPF approximately every seven days, which is approximately the time required for the SWPF to process and wash the MST/sludge resulting from seven waste feed batches (see V-ESR-J-00010⁹). After transfer, the lines can be flushed and/or vented to facilitate draining.

3.1.7 Cross-Flow Filter Cleaning

During normal operation of the filtration systems, it is anticipated that the filter flux will decrease with time, due to fouling of the filter pores with suspended and colloidal solids present in the waste. When filter performance has degraded to a point (based on observed filter flux and transmembrane pressure) where back-pulsing cannot restore filter performance, the fouled filter will be taken off-line and cleaned. Filter cleaning is expected to be required approximately once every 28 batches.

Filter cleaning effectiveness was tested during performance of the filter system full-scale test (P-RPT-J-00007, *SWPF Test Report: Cross-Flow Filter System Full-Scale Test*¹⁷). The cleaning cycle will be evaluated and optimized during Commissioning when data can be obtained from the cleaning of filters fouled with actual waste. The filter cleaning design baseline described in this Process Basis of Design is based on WSRC-TR-2003-00299 (“Alpha Removal Process Filter Cleaning Recommendations”¹⁸). The cleaning cycle steps and their respective cleaning durations are shown in Table 3-3.

Table 3-3. Filter Cleaning Cycle

Cleaning Step	Duration (minutes)
1. Drain Filter Loop	15
2. NaOH flush	66
3. Acid Wash	66-480
4. Repeat Step 3, if flux not restored	66-480
5. NaOH flush	66
Total Duration	279-1,107

Filter cleaning chemicals (0.02M NaOH and 0.5M H₂C₂O₄ or 1.0M NaOH and 20 wt% HNO₃) are transferred to the Cleaning Solution Dump Tank-A (CSDT-A) from the Filter Cleaning Caustic Tank and the Filter Cleaning Acid Feed Tank. A line from the Deionized (DI) Water Storage Tank to the CSDT-A is provided to allow for DI (water) flush of the filter loop and the CSDT-A. The CSDT-A is sized with a working volume of 850 gallons to contain a volume of cleaning solution sufficient to fill the largest filter circuit volume and maintain head in the CSDT for recirculation. The filter cleaning acid solution will be supplied from the Cold Chemicals Area (CCA) at a temperature of 104°F±5°F.

The Filter Feed/Solids Transfer Pumps (P-102-1A/B/C) and Filter Recirculation Pumps (P-102-2A/B/C) are used to circulate cleaning solution through the tube side of the filter loops. During recirculation, a small flow is returned to CSDT-A through the bleed-back and filtrate line. While the recirculation of the cleaning solution is in progress, the contents of the back-pulse tank are periodically back-pulsed into the main circuit to dislodge material on the filter tube surface or in the filter tube pores to improve cleaning efficiency.

At the conclusion of each cleaning cycle, the spent cleaning solution will be transferred to either the ASDT or the SAST, using one of the Filter Feed/Solids Transfer Pumps (P-102-1A/B/C). The ASDT collects spent caustic wash solutions, while the SAST collects spent acid solutions. The $\text{H}_2\text{C}_2\text{O}_4$ is segregated from the caustic waste streams to prevent the precipitation of sodium oxalate in the ASDT. The spent $\text{H}_2\text{C}_2\text{O}_4$ is transferred to the SSRT, following washing of the sludge when Na concentrations have been reduced. The spent HNO_3 is combined with the caustic flush solution and used for caustic dilution of the incoming waste feed.

If filter flux is not restored following acid cleaning, the acid wash may be repeated. Filter performance will be evaluated by the permeation rate of filter cleaning chemicals. If filter performance cannot be restored after repeated acid washes, replacement of the filter cartridge may be required.

The filter cleaning procedure for the Alpha Sorption Filters (FLT-222A/B/C) in the AFP is similar to the ASP filter cleaning protocol. A separate tank, Cleaning Solution Dump Tank-B (CSDT-B), is provided for AFP filter cleaning. The filter cleaning chemicals for cleaning the filters in ASP and AFP will be supplied from the same tanks. The AFP filter cleaning chemicals will also be transferred to the ASDT and the SAST after each step.

3.2 Design Basis for Caustic-Side Solvent Extraction Process

This section provides a discussion of the CSSX process operations. All volumes/flow rates are approximate and indicative for normal operation, as defined in P-ESR-J-00001⁸. Flow rates stated in this section are based on single MST strike mode, as provided in P-ESR-J-00001, unless otherwise specified.

3.2.1 Cesium Extraction

The CSSX process will use Costner Industries Nevada Corporation V-10 contactor units. These are centrifugal contactors with a nominal hydraulic capacity of 30 gpm (total aqueous and organic flow through the unit).

Extraction of Cs from the waste feed is performed in 16 successive contactors. The extraction process outlined in the preconceptual design stage (WSRC-RP-99-00006: *Bases, Assumptions, and Results of the Flowsheet Calculations for the Decision Phase Salt Disposition Alternative*¹⁹) envisioned 15 stages to achieve the required design DF of 40,000 for ^{137}Cs . For the SWPF, 16 extraction contactors are chosen to provide a measure of conservatism to ensure that, if the extraction distribution coefficients move in an unfavorable manner, the target DF of 40,000 will be achieved (see P-ESR-J-00001⁸).

Solvent flows through the extraction stages counter-current to the aqueous feed. Each individual stage provides mixing and separation of the aqueous and organic phases. Cs is transferred from the aqueous phase to the organic phase in the extraction stages. The solvent used in the CSSX process is primarily Isopar[®]L^B with a specialty extractant (BOBCalixC6)^C at 0.007M

^B The Isopar[®]L diluent is a branched 12-carbon (average) aliphatic.

^C The chemical name for the extractant is Calix[4]arene-bis(tert-octylbenzo-crown-6).

concentration, a modifier (Cs-7SB)^D at 0.75M concentration, and a suppressant (tri-n-octylamine) at 0.003M concentration. The Cs is captured by the solvent when the aqueous and organic phases are mixed and separated in the extraction stages. The Cs is stabilized in the solvent by the calixarene molecule in the extractant (BOBCalixC6). Due to the size of the opening in the calixarene molecule, Cs is removed in dramatic preference to other cations, in particular the sodium and potassium ions. The high selectivity (two orders of magnitude for K and four orders of magnitude for Na) is required to achieve the desired Cs removal efficiency.

The flow rate of CSS feed to the CSSX extraction stages will be set by the Operator, based on plant conditions and feed composition. Salt Solution Feed Pumps (P-109A/B) provide CSS feed to the extraction section from the SSFT. The Salt Solution Feed Pumps are variable-speed positive displacement pumps with a normal operating range of 5.4 – 21.6 gpm to the extraction contactors (based on P-RPT-J-00009, *SWPF Test Report: Caustic-Side Solvent Extraction Full-Scale Test*²⁰). The CSS feed is transferred through the Salt Solution Feed Cooler (HX-201) to control the feed temperature at 73°F (see WSRC-RP-99-00006¹⁹). Test data have shown that the Cs extraction process is most effective when maintained at approximately 73±5°F. The design feed flow rate to the CSS extraction section is approximately 21.6 gpm. The scrub section flow of approximately 1.4 gpm is added to the aqueous feed inlet to the extraction section. The corresponding solvent feed rate for the combined aqueous flow rate is approximately 7.2 gpm. The organic to aqueous (O:A) ratio (for solvent to extraction inlet aqueous flow) is maintained nominally at 1:3.

Solvent is fed from the Solvent Hold Tank (SHT) to the extraction stage organic inlet by one of two Solvent Feed Pumps (P-202A/B). These variable-speed positive displacement pumps have a normal operating range of 1.8 – 7.2 gpm to the extraction contactors while mixing and sampling SHT based on P-RPT-J-00009²⁰. The solvent flow set point is controlled to maintain a nominal extraction stage O:A ratio of 1:3. The pump discharge can also route solvent to the laboratory for sampling and solvent adjustment. A mixing eductor is installed in the SHT to provide homogeneity and improve the heat transfer efficiency of the tank cooling jacket.

The SHT is cooled by chilled water flowing through a cooling jacket. The Solvent Feed Coolers (HX-202A/B) on the P-202A/B pump discharge control the solvent feed temperature to the extraction contactors at 73°F. Cooling jackets are provided on the exteriors of the extraction contactors to control the aqueous and solvent temperature at 73°F.

DSS/CDCSS exits the extraction stages and gravity-flows to the DSS Stilling Tank. Small amounts of solvent are entrained with the aqueous phase from the extraction stages. In the DSS Stilling Tank, the heavier aqueous phase overflows a weir and gravity-drains to the Barium (Ba)-137 Decay Tank. The lighter organic phase overflows to the SHT. The stilling tank provides separation of the aqueous and organic phases and prevents large quantities of solvent from entering the Ba-137 Decay Tank in the event of a process upset.

The Ba-137 Decay Tank is designed to allow sufficient decay of ^{137m}Ba to effectively measure the Cs concentration prior to transfer of DSS/CDCSS to the AFP. The Ba-137 Decay Tank will

^D The chemical name for the modifier is 1-(2,2,3,3-Tetrafluoropropoxy)-3-(4-sec-butylphenoxy)-2-propanol.

have 4 quadrants. One quadrant will be filling, one will be discharging, and two will be quiescent allowing for $^{137\text{m}}\text{Ba}$ decay. One of the two Ba-137 Decay Tank Transfer Pumps (P-206A/B) will be used to transfer the DSS/CDCSS to the DSS Coalescer. The Ba-137 Decay Tank Transfer Pumps are positive-displacement, variable-speed pumps with a normal operating range of 5.75 – 23 gpm to the DSS coalescer while sampling BDT based on P-RPT-J-00009²⁰. Two in-line gamma monitors are installed downstream of the Ba-137 Decay Tank Transfer Pumps to monitor the ^{137}Cs daughter product $^{137\text{m}}\text{Ba}$ concentration. A high-gamma alarm at this location is interlocked to reroute the Ba-137 Decay Tank Transfer Pump discharge to the SSFT to ensure that high ^{137}Cs material is not sent to the AFF. The Ba-137 Decay Tank is provided with a level detectors in each quadrant to control flow into and out of each quadrant.

The DSS Coalescer recovers solvent with installed coalescing media. Recovered solvent gravity-flows to the SHT. The aqueous phase (DSS) gravity-flows to the AFF to either the IST or AST-B during single-strike operation.

3.2.2 Solvent Scrub

Following Cs extraction, the solvent is scrubbed with 0.05M HNO_3 to remove soluble salts (Na, K, aluminum, iron, and mercury) from the solvent stream. Scrubbing the metal ions from the organic prevents transfer of these ions to the strip solution. Contacting the organic stream with the dilute acid also has the effect of neutralizing any caustic carryover from the extraction stages. Neutralization of the caustic carryover is necessary to ensure stable operation of the strip stages.

Two stages of scrub are provided. The scrub solution enters the second scrub stage and proceeds counter-current to the solvent. Scrub solution is provided from the Nitric Acid Scrub Makeup Tank by one of the two Scrub Feed Pumps (P-309A/B) located in the CCA. The scrub solution flow is controlled to maintain a nominal O:A ratio of 5:1 in the scrub stages. The scrub flow rate will be approximately 1.43 gpm at the design flow.

3.2.3 Cesium Strip

The scrubbed solvent gravity-flows to the Solvent Strip Feed Tank and is pumped by one of the Solvent Strip Feed Pumps (P-217A/B) to Stripping Contactor EXT-203A. The solvent temperature is controlled to a temperature between 86°F and 96°F. Test data have indicated that the strip operation works most efficiently at 91°F to 97°F (P-RPT-J-00020, *Test Report: Cross-Flow Filter and Caustic Side Solvent Extraction Integrated Test*²¹). The strip solution is supplied to the aqueous inlet of Stripping Contactor EXT-203P from the Strip Feed Tank by the Strip Feed Pumps (P-310A/B). The strip solution passes through the associated Strip Feed Heater (HTR-310A/B), which heats the strip solution to a temperature between 86°F and 96°F.

In the strip section, Cs-laden solvent from the scrub contactors is contacted counter-current with the 0.001M HNO_3 strip solution in a series of 16 centrifugal contactors, resulting in the transfer of Cs to the strip solution. The low nitrate ion concentration in the aqueous phase shifts the equilibrium to favor the transport of the Cs ion from the solvent to the aqueous phase. The strip feed rate is controlled to a nominal O:A ratio of 5:1 to achieve a nominal Concentration Factor value of 15.

Strip effluent exits the strip stages and flows by gravity to the Strip Effluent Stilling Tank and can be pumped using the Strip Effluent Coalescer Feed Pumps, P-212 A/B to the Strip Effluent Coalescer to remove trace amounts of entrained solvent in the aqueous phase. The recovered solvent from the Strip Effluent Stilling Tank and Strip Effluent Coalescer gravity-flows to the Solvent Drain Tank (SDT). The SDT can be pumped by one of the SDT Pumps (P-208A/B) to the aqueous inlet line of the extraction stages. From there, the recovered solvent is separated from the aqueous phase during normal processing of the extraction feed.

Aqueous effluent from the Strip Effluent Coalescer gravity-flows to the Strip Effluent Pump Tank and is pumped to the Strip Effluent Hold Tank (SEHT) by one of the Strip Effluent Pump Tank Pumps (P-215A/B). The Strip Effluent Pump Tank is of minimum volume to maintain a suction head for the transfer pumps and allow tank level control.

Strip effluent is monitored for ^{137}Cs concentration and limits for the concentration of ^{137}Cs are established as part of the safety analysis for the SEHT.

The strip contactors have jackets supplied to control temperature, as required by the process. The system will be designed to maintain the contactor contents at a set point between 86°F and 96°F.

3.2.4 Caustic Wash

On leaving the strip stages, the stripped solvent flows to a caustic wash process that consists of two centrifugal contactors. Caustic wash solution is contacted counter-currently with the solvent through the two stages. The wash process is intended to remove impurities in the solvent that may interfere with solvent performance. The suppressant and modifier contained in the solvent degrade over time. The suppressant (tri-n-octylamine) forms dioctylamine and the modifier (Cs-7SB) forms a phenolic compound. The caustic wash stage is intended to remove these impurities and restore performance of the solvent. The solvent outlet from the wash stages will flow by gravity to the SHT.

The Caustic Wash Tank and one of the two Caustic Wash Tank Pumps (P-204A/B) supply caustic wash solution to the wash contactor aqueous inlet. P-204A/B are variable-speed positive-displacement pumps with a normal operating range of 0.5 – 1.4 gpm to the wash contactors while sampling Caustic Wash Tank based on P-RPT-J-00009²⁰. The operating pump will operate at a flow control set point to maintain a nominal O:A ratio of 5:1.

Caustic wash solution from the caustic wash contactors gravity-flows back to the Caustic Wash Tank. The pH of the Caustic Wash Tank will gradually decrease during operation. When the wash stage aqueous outlet pH decreases to a predetermined level (to be determined during testing and commissioning), contents of the Caustic Wash Tank will be transferred to the DSS Stilling Tank and pass out of the system with the DSS/CDCSS through the Ba-137 Decay Tank. The wash solution in the Caustic Wash Tank will then be replaced with 0.01M to 0.3M NaOH makeup provided by the Caustic Makeup Tank.

The Caustic Wash Tank level will remain approximately constant because the caustic wash solution is recirculated back from the wash stages. The tank has a working volume of 400 gallons, so caustic wash inventory should require purging and replacement on an infrequent basis. The Caustic Wash Tank has an installed overflow weir to allow recovery of any accumulated solvent. The required frequency of solvent recovery operations for the Caustic Wash Tank will be established during Commissioning. Solvent recovery is performed by adding caustic wash from the Caustic Makeup Tank to a level higher than the overflow weir. After allowing time for the tank contents to separate and settle, the overflow weir valve would be opened to recover the layer of solvent. The recovered solvent/aqueous mixture flows to the SDT.

3.2.5 Contactor Operation

Each contactor has two process inlets and two process outlets, one each for the aqueous phase and one each for the solvent phase. Both the organic and aqueous inlet and outlet ports are vented to the Process Vessel Ventilation System (PVVS). Drain and flush connections are provided at the bottom of each contactor to allow for flushing of the contactor internals. Each contactor is equipped with internal Clean-in-place (CIP) sprays to facilitate contactor cleaning and flushing. The CIP system can be supplied with process water, caustic, or HNO₃, as necessary, to promote effective flushing and removal of solids buildup. A motor with a Variable Frequency Drive (VFD) drives each contactor. The VFD will be automatically controlled by the Distributed Control System (DCS) or manually controlled by the Operator. Monitoring for the contactors include speed, motor amperage, vibration, and bearing temperature.

Contactors failure will shut down the CSSX system to minimize process upsets. If failure of a contactor appears imminent based on vibration, temperature, or other indicators, a controlled system shutdown will be performed.

A controlled shutdown allows flushing of residual Cs from the contactors by operating the CSSX on DSS feed. The contactors are then drained to the SDT. In the event of an unanticipated failure, the Operator will evaluate system performance. If sufficient time is available, a controlled shutdown is performed. If not, all contactors are shut down and the SSFT feed pumps and the solvent, scrub, strip, and wash solution feed pumps are secured. The affected contactor is then drained to the SDT. The failed contactor would then be flushed by use of CIP flush connections. Other contactors may need to be drained and flushed to reduce radiation levels to allow access to the contactor operating area.

The top portion of the contactors penetrates through a steel grating that serves as an operating platform. All maintainable parts (e.g., motors, seals, etc.) on the contactors are accessible from the platform to facilitate maintenance. The contactor housing is located under the platform. Components and piping below the platform are designed so that access is not required over the life of the plant; however, portions of the grating can be removed if required to inspect or access specific contactor components.

3.2.6 Caustic-Side Solvent Extraction Shutdown/Startup

To shut down the CSSX System, the CSSX feed is switched from CSS to DSS feed to minimize the Cs present. After operating with DSS feed for a specified period (to be determined during Commissioning), all flows will be stopped. After a brief period to drain the contactor interconnecting lines, the contactor motors will be stopped.

After CSSX shutdown for contactor maintenance, the CSSX System will be started up with DSS supplying the aqueous inlet to the extraction stages and the Ba-137 Decay Tank Transfer Pump (P-206A/B) discharge routed to the SSFT. The scrub, wash, and strip solution flows are also established. After establishing all aqueous flows, organic flow is restored at an appropriate rate. CSSX feed is switched from DSS to CSS. After stable operations are achieved with CSS feed, the P-206A/B outlet is returned to the IST or AST-B..

3.2.7 Strip Effluent Storage

The SEHT collects strip effluent for transfer to the DWPF. The SEHT is sized with a working volume of 16,600 gallons, which provides storage for at least 7 days of strip effluent production when operating at design capacity. During normal operation, the SEHT contents will be transferred to DWPF approximately once every seven days, in order to match the DWPF operating cycle (V-ESR-J-00010⁹). Capability exists to transfer to DWPF on a more frequent basis.

The ¹³⁷Cs concentration in the SEHT is approximately 15 times higher than CSS feed. The concentration of ¹³⁷Cs in the SEHT generates sufficient heat to require tank cooling. The SEHT is cooled by PCHW circulated through a cooling jacket installed on the vessel.

The SEHT is agitated by in-tank eductors. Mixing is performed as needed to ensure tank homogeneity and promote heat transfer to the jacket. Flow to the eductors is provided by one of two Strip Effluent Transfer Pumps (P-205A/B). The tank is sampled prior to transfer to DWPF to ensure compliance with the DWPF WAC. Pumps P-205A/B are also used for transfer to DWPF. These are centrifugal pumps with a design capacity of 300 gpm. The transfer requirements for strip effluent are specified in V-ESR-J-00010⁹.

During routine operation, some solvent is expected to be carried forward into the SEHT. The SEHT has a solvent recovery weir that functions similarly to that described for the Caustic Wash Tank. Overflow from the weir flows to the SDT. The required frequency of solvent recovery will be evaluated during Commissioning.

3.3 Design Basis for Alpha Finishing Process

This section describes the process operations for waste requiring additional MST strike(s) in the AFP. Descriptions of the equipment required to perform these operations are provided, along with information on tank/equipment sizing requirements, where appropriate. Because most of the operations in the AFP are similar to corresponding operations in the ASP, the appropriate ASP operations are referenced. The purpose of the AFP is to remove Sr and actinides that may

still be present in the CDCSS at levels exceeding the Saltstone WAC limits. An additional MST strike can be performed in the AFP with no impact to plant design throughput. Because the Cs concentration in the feed to AFP is significantly lower than that in the ASP, AFP equipment is designed to allow contact-handled operations and maintenance.

During single-strike operations, DSS in the Ba-137 Decay Tank is pumped to the DSS Coalescer. DSS from the DSS Coalescer gravity-flows to either the IST or AST-B. During single-strike operation, the IST and AST-B are alternately used to receive and stage DSS for transfer to the DSSHT. These tanks also provide a convenient point for sampling of the DSS to verify compliance with the Saltstone WAC. Once the receiving tank is full, the flow is switched to the alternate tank and the isolated tank is sampled. The DSSHT stores the DSS product until the tank is pumped to the Saltstone Feed Facility (SFF) and subsequently to the SPF. If material is transferred to the IST or AST-B that does not meet the SPF WAC during single-strike operation, a second strike can be performed or the material is recycled to the ASP section for additional processing.

During multi-strike operations, CDCSS from the DSS Coalescer gravity-flows to the IST. IST contents are then transferred to AST-B to perform a second MST strike. After the MST adsorption period has been completed, AST-B is sampled and analyzed to verify that the Sr/actinides and Cs in solution meet the SPF WAC limits. If the WAC limits are satisfied, the AST-B contents are transferred to FFT-B for filtration. If WAC limits are not met, additional strikes can be performed or material can be recycled to the ASP section for additional processing. Filtrate from the filtration process is routed to the DSSHT. The DSSHT contents are transferred to the SPF via the SFF once per day (refer to V-ESR-J-00010⁹ for details).

3.3.1 Intermediate Storage Tank

The IST receives DSS (single strike) or CDCSS (double strike) from the Ba-137 Decay Tank and transfers the material to either the DSSHT or AST-B for a single or double strike, respectively. The working volume of the IST is 30,300 gallons. One of the two IST Transfer Pumps (P-220-A/B) is used to transfer CDCSS/DSS from the IST to either AST-B or DSSHT. These pumps are centrifugal pumps with a design capacity of 400 gpm. The IST is equipped with eductors fed off a recirculation loop from P-220A/B for tank mixing.

The IST has a sample pump installed that allows pumped recirculation of material to the Analytical Laboratory for analysis. The IST Sample Pump (SP-220) is a 25-gpm positive-displacement pump with a variable-speed drive. The outlet is normally recirculated to the Analytical Laboratory for sampling. The discharge of SP-220 can also be routed to the SDT for solvent recovery. It is expected that, during normal operations, a thin layer of solvent may accumulate on the surface of contents in the IST. To recover solvent, the tank contents are pumped down to a minimum level (on the order of 100-200 gallons), using P-220A/B. The sample pumps are then used to transfer the remaining contents to the SDT, where the mixed solvent/aqueous waste can be recovered by pumping to the CSSX extraction process.

3.3.2 Strontium and Actinide Adsorption in Alpha Sorption Tank-B

As described in Section 3.3, AST-B is used as a receiving vessel during single-strike operations, or to perform a second strike during a double-strike campaign. The working volume of AST-B is 30,700 gallons. Following completion of a batch transfer from the IST to AST-B during double-strike mode, sufficient MST/slurry at 15 wt% is added to achieve a concentration of 0.4 g/L. A dilute caustic flush from the Caustic Dilution Feed Tank is performed to flush the MST addition line from the CCA. The adsorption time is six hours. The contents are mixed with a mechanical agitator (AGT-221) during the adsorption period. DFs used in P-ESR-J-00001⁸ for both single- and multi-strike operation are provided in Table 3-1. AST-B has a cooling jacket to remove the heat of mixing.

The AST-B contents are sampled and analyzed after MST adsorption to ensure that the filtered concentrations of Sr and actinides will be within the Saltstone WAC limits. For cycle timing calculations, an eight-hour turnaround time is conservatively assumed for sampling and analysis in AST-B. Because there are no caustic or wash water addition steps, the overall AST-B cycle time is approximately 21.6 hours, which is the same as the AST-A single-strike cycle time. Table 3-4 shows the duration of each process step in AST-B for the double-strike mode.

Table 3-4. Alpha Sorption Tank-B Cycle Time – Two Monosodium Titanate Strikes

Operational Step	Volume ¹ (gallons)	Flow Rate (gpm)	Time ¹ (hours)
CDCSS Delivery from IST to AST-B	29,844	300	1.66
MST Addition	76	5	0.25
Mix/Reaction	N/A	N/A	6
Operation Verification	N/A	N/A	2
Sampling and Analysis ²	N/A	N/A	8
Contingency	N/A	N/A	2
Transfer from AST-B to FFT-B	29,920	300	1.66
Line Flush	100 ³	100	0.02
Total Cycle Time			21.59
Notes:			
1. Volumes and times are based on MST loading of 0.4 g/L.			
2. It is assumed that the sample collection will be performed in AST-B.			
3. Line flush approximated.			

After the AST-B contents have been qualified, they are transferred to FFT-B, using one of the two AST-B Transfer Pumps (P-221 A/B). These pumps are centrifugal pumps with a design capacity of 300 gpm.

AST-B has a sample pump configuration similar to that of the IST. The AST-B Sample Pump (SP-221) allows for sampling and solvent recovery. Discharge from the pumps can be routed to either the Analytical Laboratory or the SDT.

3.3.3 Filtration

Similar to FFT-A in the ASP, FFT-B is used to concentrate waste processed in AST-B during double-strike operation. FFT-B has a working volume of 31,900 gallons, which accommodates one batch from AST-B and six concentrated FFT-B batches. The contents of FFT-B are circulated through two of the three CFFs to concentrate the MST solids to 5 wt%. A mechanical agitator (AGT-222) is used to mix the MST slurry in FFT-B. The size and operation of the CFFs, back-pulse tanks, and pumping system for the AFP filter systems are identical to the ASP. The AFP filter systems will differ in that they are designed with flanged connections to allow for removal of the entire filter assembly, as opposed to removal and replacement of the cartridge, as is planned for the ASP.

Similar to ASP, multiple batches will be accumulated in FFT-B at lower than 5 wt% solids to facilitate level monitoring and mixing. The final (seventh) batch will be concentrated to the target concentration of 5 wt% and transferred to the MSTT.

Filtrate from the AFP Alpha Sorption Filters (FLT-222A/B/C) is routed to the DSSHT. The filtrate flow line is equipped with a turbidity instrument to provide indication of filter breakthrough. Similar to the ASP, the filtrate flow can be returned to FFT-B during filter start-up operations or in the event of a filter breakthrough.

FFT-B has a sample pump configuration similar to that of the IST. The FFT-B Sample Pump (SP-222) allows for sampling and for solvent recovery. Discharge from the pumps can be routed to either the Analytical Laboratory or the SDT.

3.3.4 MST/Sludge Transfer Tank

Following concentration in FFT-B, concentrated MST slurry is transferred to the MSTT for interim storage and subsequent transfer to the SSRT for washing. Transfers to the SSRT from the MSTT will normally coincide with transfers of concentrated MST/sludge from FFT-A.

The working volume of the MSTT is 1,600 gallons. This accommodates the combined volumes of seven batches from the FFT-B and line flush volume. The MSTT is equipped with an agitator (AGT-224) to keep the MST/sludge in suspension and also with a cooling jacket to remove the heat generated by the agitator. MST/sludge is transferred to the SSRT with the MST/Sludge Transfer Pump (P-224), which has a design capacity of 60 gpm.

3.3.5 Decontaminated Salt Solution Storage and Transfer

The DSSHT receives DSS from the IST and AST-B during single-strike operation, and filtrate from FFT-B during double-strike operation. The DSSHT is required to store DSS generated by 24 hours of operation at design capacity. At a design DSS production rate of 23 gpm, the DSS

produced after 24 hours of operation would be approximately 33,000 gallons. The DSSHT has been conservatively sized to provide a working volume of 35,900 gallons (approximately 26 hours of DSS production). The DSSHT contents will be transferred to the SFF once every IST/AST-B cycle (approximately 21.6 hours).

One of the two DSSHT Transfer Pumps (P-207A/B) will be used to transfer DSS to the SPF via the SFF. Pumps P-207A/B have a capacity of 400 gpm. These Transfer Pumps are also used to recirculate DSS through mixing eductors installed in the DSSHT. The eductors are installed to ensure that the tank is well mixed prior to sampling. Transfer line pressure is controlled to meet the destination requirements. The transfer requirements for DSS are specified in V-ESR-J-00010⁹.

The DSSHT has a sample pump configuration similar to that of the IST. The DSSHT Sample Pump (SP-207) allows for sampling and for solvent recovery. The discharge from the pumps can be routed to either the Analytical Laboratory or the SDT.

3.3.6 Filter Cleaning

During routine operation, it is anticipated that the filter flux will decrease as each FFT-B batch is processed. When the filter flux decreases significantly below a predetermined operating limit (to be determined during Commissioning), the fouled filter is isolated and cleaned to restore normal operation. The cleaning procedure will be identical to the procedure used for cleaning the ASP filters (see Section 3.1.7). The design basis frequency of cleaning these filters is assumed to be same as for ASP filters (i.e., once every 28 batches). CSDT-B provides an identical function in the filter cleaning process for the AFP as CSDT-A provides in the ASP.

3.4 Cold Chemicals Area

3.4.1 Monosodium Titanate Receipt, Storage, and Transfer

MST will be received and stored in the MST Storage Tank in the CCA. A drum tumbler (DT-311) and mechanical agitator (AGT-311-1) are provided to mix and agitate MST in the drums prior to transfer to the MST Storage Tank, using the MST Drum Pump (P-311-1). AGT-311 is installed in the MST Storage Tank to mix and prevent settling of MST in the tank. The MST Storage Tank is sized to provide sufficient MST to process approximately 11 AST batches when the plant is operated in single-strike mode.

MST is transferred from the MST Storage Tank to AST-A or AST-B by the MST Transfer Pump (P-311). The amount added will depend on the volume of solution in the tank, the desired MST concentration, and the concentration of MST in the MST Storage Tank. P-311 and the MST transfer lines are flushed with 1.66M dilute caustic after each transfer to either AST-A or AST-B.

3.4.2 Sodium Hydroxide (Caustic) Receipt, Storage, and Transfer Systems

3.4.2.1 Caustic Receipt Tank

The Caustic Receipt Tank will receive deliveries of concentrated (50 wt%) NaOH from tanker trucks. The Caustic Receipt Tank is sized with a working volume of 8,000 gallons, which provides sufficient caustic for approximately 10 days of operation.

The 50% Caustic Transfer Pump (P-302) supplies metered quantities of NaOH to the Caustic Dilution Feed Tank, Caustic Makeup Tank, Filter Cleaning Caustic Tank, and the Neutralization Tank. P-302 is a centrifugal pump with a design capacity of 150 gpm. The pump recirculates through a loop providing a pressurized supply to the users. Flow meters are installed on the transfer lines off the recirculation loop to supply the Caustic Dilution Feed Tank, Caustic Makeup Tank, Filter Cleaning Caustic Tank, and the Neutralization Tank.

The Caustic Receipt Tank is equipped with a heater to maintain tank temperature at 90°F. Fifty percent (50%) caustic solution viscosity increases as the temperature decreases and lower temperatures will impact the ability to transfer the material. The recirculation line to the tank returns flows through a mixing eductor (EDT-302) to maintain tank homogeneity and facilitate heating. All piping containing 50 wt% caustic is heat-traced.

3.4.2.2 Caustic Dilution Feed Tank

The Caustic Dilution Feed Tank is used to prepare 1.66M NaOH primarily for chemical adjustment of AST-A during the alpha sorption reaction. The Caustic Dilution Feed Tank is sized with a working volume of 8,000 gallons to provide sufficient volume for chemical adjustment of two AST-A batches. Dilute caustic batches will be prepared automatically when initiated by Operations personnel. Appropriate volumes of 50 wt% caustic and PW are added through totalizing flow meters. The final composition can be verified on-line by installed density instrumentation and adjusted as needed by automatic additions of caustic or water. The tank can be sampled periodically for laboratory verification of tank contents.

The Caustic Dilution Transfer Pump (P-108) transfers dilute caustic from the Caustic Dilution Feed Tank to AST-A. P-108 has a design capacity of 100 gpm. P-108 is also used for flushing of the MST addition lines from the MST Storage Tank to either AST-A or AST-B.

3.4.2.3 Filter Cleaning Caustic Tank

The Filter Cleaning Caustic Tank is used to prepare dilute caustic at 0.02M or 1.0M for filter cleaning, as described in Section 3.1.7. The working volume of this tank is 850 gallons, which provides adequate caustic to completely fill the largest filter loops in ASP and AFP. Caustic is made up in the Filter Cleaning Caustic Tank, similar to the method described for the Caustic Dilution Feed Tank, except that a conductivity probe is used to adjust and verify tank caustic concentration.

The Filter Cleaning Caustic Tank Pump (P-107) is used to transfer 0.02M or 1.0M caustic to CSDT-A/B. P-107 has a design capacity of 50 gpm. The Filter Cleaning Caustic Tank Heater (HTR-107) is installed to heat the tank contents prior to transfer to the filter loop. The Filter Cleaning Caustic Tank is equipped with an agitator to mix the tank contents and facilitate heating.

3.4.2.4 Caustic Makeup Tank

The Caustic Makeup Tank is used to prepare 0.01M to 0.3M caustic wash solution for the CSSX wash process. The working volume of this tank is 2,000 gallons, which provides sufficient volume to refill the Caustic Wash Tank five times. Makeup to the Caustic Makeup Tank is performed similarly to the method described for the Caustic Dilution Feed Tank, except that the tank contents will be verified and adjusted by utilizing an installed conductivity analyzer. Adjustment can be made by adding caustic and/or DI water through actuated valves, as necessary.

The Caustic Makeup Transfer Pump (P-303) is used to transfer caustic wash solution to the Caustic Wash Tank. P-303 has a design capacity of 50 gpm. The Caustic Makeup Tank is equipped with a mechanical agitator to mix the tank contents.

3.4.3 Nitric Acid Receipt, Storage, and Makeup System

3.4.3.1 Nitric Acid Receipt

Twenty percent (20 wt%) HNO_3 (3.54M) will be received in bulk by tanker truck and pumped to the Nitric Acid Receipt Tank. The estimated usage of 20 wt% HNO_3 in CSSX is 900 gallons per month. The Nitric Acid Receipt Tank has a working volume of 2,000 gallons, which is sufficient HNO_3 for approximately 2 months of CSSX operation. The Nitric Acid Metering Pump (P-304-1) is operated continuously to make up scrub solution in the Nitric Acid Scrub Makeup Tank during operation of the CSSX process. P-304-1 has a normal operating range of 0.007-0.02 gpm to the Nitric Acid Scrub Makeup Tank. .

The Neutralization Metering Pump (P-304-2) is used to provide HNO_3 to the flush header during flushing operations and to transfer HNO_3 to the Neutralization Tank, if necessary, for neutralization of collected waste. P-304-2 has a normal operating range of 10-60 gpm to the flush header or neutralization tank. It also can be used as an alternate make-up pump for scrub solution.

3.4.3.2 Nitric Acid Scrub Makeup (0.05M)

The Nitric Acid Scrub Makeup Tank provides scrub solution to the scrub section of the CSSX process. Scrub usage is approximately 2,000 gallons of scrub solution per day. The Nitric Acid Scrub Makeup Tank is sized with a 2,100-gallon working volume. The Scrub Feed Pumps (P-309A/B) supply the scrub section of the CSSX process from the Nitric Acid Scrub Makeup Tank. P-309A/B are positive-displacement pumps with a normal operating range of 0.5 – 1.4

gpm to the scrub contactors. P-309A/B will normally run to maintain an O:A of 5:1 in the CSSX scrub section.

Nitric Acid Metering Pump (P-304-1) and Scrub Water Feed Pump (P-312-2) are normally operated to maintain the Nitric Acid Scrub Makeup Tank level at approximately 80%. In the event of equipment failure or required maintenance on the makeup pumps, sufficient inventory is available to take the makeup system out of service for a day. DI water is added, based on tank level indication. The Nitric Acid Scrub Makeup Tank conductivity is monitored with redundant conductivity analyzers to provide feedback to control the addition rates of 20 wt% HNO₃ with P-312-2. The 20 wt% HNO₃ addition flow rate will be approximately 1.5% of the DI water flow to maintain the HNO₃ concentration in the Nitric Acid Scrub Makeup Tank at 0.05M. An agitator is installed in the Nitric Acid Scrub Makeup Tank to ensure that tank contents are well mixed.

3.4.3.3 Nitric Acid Strip (0.001M)

Dilute HNO₃ at 0.001M is provided to the aqueous inlet of the strip stages by the combined flow from one of the Strip Feed Pumps (P-310A/B) and Strip Water Feed Pumps (P-312-3A/B). P-310A/B supply dilute HNO₃ from the Scrub Feed Tank. This flow is diluted to the proper molarity (0.001M) for the strip section by addition of DI water from P-310A/B. Pumps P-310A/B are variable-speed positive-displacement pumps with a normal operating range of 0.007 - 0.028 gpm to the strip contactors. Strip feed equipment is arranged in parallel systems to provide full redundancy. P-312-3A/B are variable-speed positive-displacement pumps with a normal operating range of 0.5 – 1.4 gpm to the strip contactors. The pumps will be operated to maintain a nominal O:A ratio of 5:1 in the stripping section. The output from P-312-3A/B and P-310A/B is mixed with one of the static mixers (MIX-310A/B). Dual conductivity probes installed after the mixers provide an indication of HNO₃ molarity. The flow rates of the two pumps are adjusted to maintain the combined molarity at 0.001M at the set point flow rate. The HNO₃ addition rate is controlled by the conductivity, while the water addition rate is controlled by strip solution flow indication. During normal operation, the relative flow rate of scrub makeup to DI water to mix strip feed at the proper concentration will be approximately 50:1. Heaters are installed after MIX-310A/B to heat the strip feed between 86°F and 96°F.

The strip solution removes Cs from the solvent flowing counter-current into the strip stages. The aqueous outlet (strip effluent) from the strip stages is sent to the SEHT. At the design strip solution flow rate of 1.44 gpm, the strip solution usage will be approximately 2,000 gallons per day. This corresponds to approximately 40 gallons per day of scrub solution at 0.05M used to mix the strip feed at 0.001M.

3.4.4 Filter Cleaning Acid Receipt, Storage, and Transfer

H₂C₂O₄ or HNO₃ can be used in the acid wash step of the filter cleaning process, as described in Section 3.1.7. H₂C₂O₄ at 0.5M or 20wt% HNO₃ will be received in bulk by tanker truck and transferred to the Filter Cleaning Acid Feed Tank. The Filter Cleaning Acid Feed Tank has a working volume of 3,400 gallons to provide sufficient filter cleaning acid for approximately four filter cleaning cycles.

Acid from the Filter Cleaning Acid Feed Tank is transferred to CSDT-A or CSDT-B with the Acid Transfer Pump (P-106). P-106 has a design capacity of 50 gpm. Filter Cleaning Acid is transferred to either CSDT-A or CSDT-B as part of an automated filter cleaning sequence.

3.4.5 Solvent Makeup

The solvent used in the CSSX process is primarily Isopar[®]L with a specialty extractant (BOBCalixC6) at 0.007M concentration, a modifier (Cs-7SB) at 0.75M concentration, and a suppressant (tri-n-octylamine) at 0.003M concentration. The minimum volume of solvent required for CSSX operation is approximately 300 gallons. The SHT has a working volume of 500 gallons.

The SHT requires approximately 8 batches of 50 gallons each from the Solvent Makeup Tank for initial fill. The solvent will be made up in either the Solvent Makeup Tank by Operations personnel or received in pre-mixed 55-gallon drums. The concentrations of the diluent, extractant, modifier, and suppressant in the CSSX will be determined by periodic sampling and analysis of the SHT. The Solvent Makeup Transfer Pump (P-313) transfers solvent from the Solvent Makeup Tank to the SHT. The quantities of solvent constituents required for initial solvent fill are shown in Table 3-5.

Table 3-5. Solvent Makeup Tank Constituents Mix Ratio

Constituent	Quantity Required for 50-Gallon Mini-Batch (grams)	Total for 400-Gallon Batch (grams)
Extractant	1,524	12,192
Modifier	48,046	384,360
Suppressant	201	1,608
Isopar [®] L (balance)	107,322	858,574
Note: Additions of reagents to adjust molarity of solvent may require the use of Isopar [®] L as a carrier.		

Capability is provided for addition of small quantities of extractant, modifier, or suppressant, if sampling and analysis show that one or more of these chemicals are depleted during CSSX operation. A recirculation flow from the SHT to Hot Cell #2 in the Analytical Laboratory can be routed through the Solvent Adjustment Filter (FLT-250). BOBCalixC6, which is a solid, can be added to the filter by using a Hot Cell manipulator. Solvent is then recirculated from the SHT through FLT-250 to dissolve the BOBCalixC6. A heater installed before the filter raises the solvent temperature to facilitate dissolution of the BOBCalixC6. The solvent then returns to the SHT, where it mixes with the CSSX bulk solvent inventory. This filter (FLT-250) can also be used as a continuous filter for the solvent. The solvent system can be configured so that a side stream of solvent can continuously recirculate through the sample loop and FLT-250. Continuous filtering of the solvent can be accomplished while the CSSX System is operating.

Liquid solvent component adjustments (modifier and suppressant) are made through an addition pot accessible on the CSSX Tank Cell Operating Deck. The addition pot inlet valve is opened to add the component to the pot through a funnel. The inlet valve is then closed and the outlet valve opened to drain the addition pot contents to the SHT. Isopar can be added through the addition pot or from the Solvent Makeup Tank in the CCA. Solvent is expected to be lost in very small quantities due to minimal solubility in the aqueous flow streams and losses through the ventilation system.

3.4.6 Neutralization Tank

The Neutralization Tank has two purposes: 1) neutralization of waste collection in CCA sumps, and 2) dilution of 50 wt% caustic for addition to either the ASDT, SEHT, and other users. Acid or caustic waste liquid can be transferred from the CCA collection sumps to the Neutralization Tank. The Neutralization Tank has acid and caustic addition lines that allow neutralization of collected liquid in preparation for disposal or transfer. Waste can be transferred back into the process via the ASDT, or transferred to alternate locations via a hose connection (e.g., drums, tanker, or the sewer), as permitted.

The Neutralization Tank is also used for addition of caustic to the ASDT or SEHT for chemical adjustment. Concentrated caustic is transferred to the Neutralization Tank and diluted to approximately 20 wt% in preparation for transfer to either the ASDT or the SEHT.

The Neutralization Tank Discharge Pump (P-317) is used to transfer material from the Neutralization Tank. P-317 is a centrifugal pump with a design capacity of 25 gpm. A recirculation loop with pH meter is installed for tank mixing and analysis.

3.4.7 Process Water System

The Process Water System is supplied from the domestic water (DW) header and distributes PW to plant users through the PW supply header. The Process Water Tank has an 8,000-gallon working volume. The Process Water Utility Pump (P-301-1) and Process Water Flush Pump (P-301-2) are used to supply the Process Water System. P-301-1 and P-301-2 have design capacities of 75 and 300 gpm, respectively. The Process Water System supplies a number of users including the SSRT (for sludge washing), the flush header, pump seal makeup, Caustic Dilution Feed Tank, wet sump makeup, heat recovery water system, makeup to chiller systems, and building utility drops.

The Process Water System is maintained at approximately 80 to 90 psig by the Process Water Pressure Tank. The Process Water Pressure Tank is a 400-gallon tank that is pressurized by the Plant Air System.

3.4.8 Flush Water System

The Flush Water System provides flush water to SWPF vessels, equipment, cells, liners, and labyrinth areas. Flush water is used to spray down process vessel internals, cell and labyrinth areas to reduce contamination levels, and flush process equipment in preparation for contact

maintenance. The Flush Water System is fed from the Process Water System and uses P-301-1 and P-301-2 as supply pumps.

The system will normally be maintained at the same pressure as the Process Water System via the Process Water Pressure Tank. Hard-piped flush connections to contaminated waste piping allow flushing for maintenance or access to labyrinth areas.

Typically, flushes will be performed with PW only. Connections are provided to allow the injection of 50 wt% caustic or 20 wt% HNO₃ during the flush operations, if necessary. This activity is expected to be required on a very infrequent basis. To strictly control the ability to add HNO₃ or caustic to the flush water header, piping spool pieces provided on the HNO₃ and caustic injection lines will be disconnected from the flush header. Connection will be strictly controlled by Operations personnel.

3.4.9 Deionized Water System

A skid-mounted DI water system will be provided to supply DI water for the CSSX and filter cleaning makeup tanks. The DI water system is supplied from the DW header. DI water is supplied to CSDT-A and CSDT-B, Nitric Acid Scrub Makeup Tank, Filter Cleaning Caustic Tank, Caustic Makeup Tank, Filter Cleaning Acid Feed Tank, and the stripping section of the CSSX process (with an HNO₃ bleed) as strip feed makeup.

The deionizers will be located outside the building and trailer-mounted to facilitate removal and replacement. An alarm and monitoring panel is available locally with general trouble alarms routed to the facility DCS. The DI Water Storage Tank has a 6,000-gallon working volume. This is sufficient volume to provide for more than a day of operation of the CSSX process, not including the additional volume of scrub solution that would normally be maintained in the Nitric Acid Scrub Makeup Tank.

The DI water header is supplied by the DI Water Transfer Pump (P-312-1) which has a design capacity of 100 gpm. The pump will operate on demand to supply a pressurized recirculation loop back to the DI Water Storage Tank. A flow meter with totalizing capability is installed on the supply header to allow automatic makeup of chemical supply tanks.

3.5 Waste Transfer System Design

Waste transfer pumping and piping systems are designed for a flow velocity greater than or equal to 4 ft/sec. The design transfer rate between facilities is in the range of 100 to 200 gpm. All waste transfer pipelines within the EPC's scope between the SWPF and other facilities is to be of the pipe-in-pipe design, with a stainless steel primary pipe inside a carbon steel encasement pipe. The transfer lines for MST/sludge transfers from SWPF shall have the capability of being flushed post transfer.

Two pneumatically actuated isolation valves are provided in the Waste Transfer Enclosure (WTE) to isolate incoming transfer lines. Actuated valves in the WTE and the labyrinth areas are available to provide multiple valve isolation when required (i.e., venting of the strip effluent

line when in standby is required). The WTE is provided with leak detection and alarm capability.

All remotely operated valves in the SWPF associated with the transfer flow path will have position indication devices that provide status to the SWPF Control Room (CR). Information regarding valve and equipment status shared between areas (e.g., pump status, tank levels) and interlocks associated with inter-area waste transfer is specified in V-ESR-J-00010⁹.

3.6 Waste Containment Design

3.6.1 Alpha Sorption Process Containment Design

The majority of liquid radioactive material in the SWPF is contained in process vessels located in the Process Vessel Cells. These cells are constructed with reinforced concrete floors and walls. The cell floors have stainless steel liners and sumps to contain and collect liquid waste. The cells are maintained at a negative pressure by the Building Ventilation System.

The Central Processing Area cells include the following:

- AST-A Cell,
- FFT-A Cell,
- ASDT Cell,
- SSRT/WWHT Cell,
- SSFT Cell, and
- SEHT Cell.

Any in-cell leakage is collected and detected in the vessel cell sumps. The Process Vessel Cell sumps normally contain PW to provide a liquid seal for the process vessel overflows. The sumps can be evacuated by the ASP Sump Transfer Pump (P-110) to the SSRT, ASDT, or the Drum Off Station. The discharge of P-110 can also be directed to the Analytical Laboratory to allow for sampling of the sump contents.

Radioactive liquid waste is routed between vessels and equipment through the ASP Pump and Valve Galleries (P&VGs). The P&VGs contain transfer pumps, valves, process instrumentation, and support equipment (e.g., process heaters and coolers). The ASP labyrinth area sumps collect leakage in the labyrinth areas from the process pumping systems and gravity-drain to the ASDT. A designated drain line from the pump casing drains goes directly to the ASDT. The drain lines from each labyrinth sump are designed to allow a flow equal to the largest of the labyrinth area flush flow rate or the largest expected leak from the process piping system. Labyrinth floors are sloped to ensure that leakage is contained within the labyrinth areas and directed to the drains. The drain headers have loop seals installed to prevent the inflow of air to the ASDT during normal operation and back-migration of contamination from the ASDT to the labyrinth areas in which personnel may be located.

The labyrinth sumps are designed with auto-siphon devices that allow testing of leak detection instrumentation during operation, while maintaining a flow path for large process leaks. The auto-siphon devices allow liquid collection to a certain elevation and then automatically siphon the liquid to a low level, clearing the alarm. If liquid is detected in the sump, alarms will be annunciated indicating the location of the leak, and interlocks will be actuated that shut down and isolate that pumping system, as appropriate.

ASDT overflow is routed to the ASDT Cell. The ASDT Cell has a sump that can be evacuated by the ASP Sump Transfer Pump (P-110). The ASDT Cell is designed to contain the full volume of individual process vessels. The ASDT contents are evacuated by using the ASDT Discharge Pumps (P-601A/B), which have a design capacity of 50 gpm. The ASDT contents can be transferred to the WWHT, AST-A, SSRT, or the Drum Off Station.

3.6.2 CSSX Section Containment Design

The majority of liquid radioactive material in the CSSX section is contained in process vessels located in the CSSX Tank Cell. The CSSX Tank Cell is divided into east and west sides that are separated by a concrete wall. The east side contains the higher-activity tanks and the west side contains tanks of lower activity. The cells are constructed with reinforced concrete floors and walls and stainless steel liners. The East CSSX Tank Cell has a removable cover block to allow access. A personnel access door is provided to the West CSSX Tank Cell.

The east side of the CSSX Tank Cell is designed so that access is not required over the life of the plant. Limited access is provided on the west side of the CSSX Tank Cell to allow for maintenance of the Strip Effluent Coalescer media, pumps, and valves. The head of the Strip Effluent Coalescer is accessible from the west CSSX Tank Cell through the dividing wall between the two CSSX Tank Cells. The CSSX is a clean (i.e., solids-free) process, so maintenance on the coalescer media is expected to be required on a very infrequent basis.

The east and west sides of the CSSX Tank Cell each have a designated sump and level instrumentation. The CSSX sumps normally contain PW to provide a liquid seal for the process vessel overflows. The sumps are evacuated by the CSSX Tank Cell Sump Pump (P-218) to the SDT. An overflow to the SDT is provided.

Pumps associated with the CSSX section are arranged in labyrinths similar to the ASP area. The CSSX labyrinths have identical design features in terms of sump level instrumentation, interlocks, and auto-siphon devices. CSSX area labyrinth sumps drain to the SDT, instead of the ASDT, to minimize the potential for entry of solvent into the ASP section. Drainage of the CSSX labyrinths to the SDT in the ASDT Cell minimizes fire hazards associated with a leak of solvent into the CSSX labyrinths by limiting the potential accumulation of solvent.

CSSX contactors are installed on the Contactor Support Floor. The Support Floor is lined with stainless steel and drains to the SDT. Leakage in the CSSX Contactor Area drains to the SDT.

3.6.3 Alpha Finishing Facility Containment Design

The majority of liquid radioactive material in the AFP section is contained in process vessels located in lowered containment sumps. The sump floors are at the +95-foot (ft) 3-inch elevation, which is below the AFP operating elevation. The lowered elevation provides sufficient volume to contain the volume of the largest tank in each sump, plus a margin for conservatism.

The IST and AST-B share a common sump. The DSSHT, FFT-B, and MSTT share two common sumps. Sump pumps installed in each sump area can evacuate the sump contents. Each sump has level instrumentation that provides a high-level alarm to the CR.

The Alpha Finishing Drain Tank (AFDT) is located in a lowered sump area to collect pump drainage and spent filter cleaning solution from the back-pulse tanks. AFDT has a working volume of 1,400 gallons. The AFDT contents are pumped out with Alpha Finishing Drain Tank Transfer Pump (P-228) with a design capacity of 25 gpm. The AFDT contents are pumped to AST-B. P-228 discharge can be recirculated to the Analytical Laboratory for sampling.

3.6.4 Waste Transfer Enclosure

The waste feed, MST/sludge, and strip effluent transfer lines are routed into or out of the SWPF Process Building through the WTE. This enclosure has a stainless steel liner and is partially below grade to allow waste transfer lines to enter/exit the external wall of the WTE at least four ft below grade. The WTE is provided with a sump and a leak detector. The WTE is equipped with a removable shield cover, if access is necessary. The sump can be pumped to the ASDT, SSRT, facility Drum Off Station, or Analytical Laboratory Hot Cell (for sampling) by the ASP Sump Transfer Pump (P-110). The WTE is vented to the SSFT Cell to provide negative pressure and allow the venting of gases that may accumulate.

3.7 Confinement Design

The Process Building Ventilation System (PBVS) is a once-through exhaust system that maintains a cascading air flow from normally occupied areas (non-contaminated) to potentially contaminated areas (process support areas and process cells). Air is drawn into the Process Vessel Cells by the negative pressure created by the two Process Building Exhaust Fans (FAN-001 or FAN-002). The exhaust air passes through HEPA filters and is directed to the Exhaust Stack.

The PVVS maintains a negative pressure in ASP and CSSX process vessels and contactors of approximately -10 inches water column. The Process Vessel Vent Exhaust Fans (FAN-401A/B) draw air from the process vessels and through HEPA filters before being exhausted to the Exhaust Stack. Orifices typically installed on each tank allow an in-bleed of air from the Process Vessel Cells that sweeps flammable gases from the tank head space. The negative pressure in the process tanks and contactors prevents release of airborne contaminants into the Process Vessel Cells, CSSX Tank Cell, and CSSX Contactor Area.

The AFF process vessels are vented to the Alpha Finishing Vent Header, which vents through a passive ventilation HEPA filter with integral demister (FLT-207). As tanks are filled and drained, air is either drawn in or exhausted through the AFF ventilation header to the building ventilation system.

The PMVS maintains a negative header pressure of approximately -36 inches water column to allow low-level operation of the pulse mixers and increased pulse mixer cycle times. The Pulse Mixer Vent Exhaust Fans (FAN-402A/B) draw air from the pulse mixer vent header and through HEPA filters before being exhausted to the Exhaust Stack. The PMVS maintains confinement and filtration of the air vented from pulse mixers installed in process vessels. Section 3.1.2.1 describes operation of the process vessel APAs in more detail.

The Confinement Systems including the PBVS, PVVS, and PMVS are described in more detail in P-DB-J-00004¹.

3.8 Miscellaneous Process Systems

3.8.1 Low Level Drain Tank

Drains outside the main processing areas that could potentially contain low levels of contamination or materials incompatible with the SWPF processes are directed to the Low Level Drain Tank. These areas include safety shower drains, drains from the personnel decontamination (decon) room, CSSX and ASP P&VG corridor drains, and other miscellaneous drains.

The Low Level Drain Tank, which is located on a recessed floor area of the AFF, has a working volume of approximately 200 gallons. The tank contains level instrumentation and alarms to allow monitoring of the tank level by the CR. The Low Level Drain Tank Transfer Pump (P-604) is used to evacuate the sump contents either to the Truck Bay, ASDT, Drum Off Station, Lab Collection Tanks, or DSSHT. P-604 has a design capacity of 60 gpm.

3.8.2 Decontamination (Decon) Area

A Decon Area (Drum Off/Decon Area) is provided to allow decontamination of process equipment and miscellaneous plant items. Decon may be undertaken prior to performing maintenance on or shipping an equipment piece or component out of the SWPF. Decon activities will be performed in Radiologically Posted Areas with temporary containment and ventilation exhaust enclosures established for the specific decon activity that is planned. Plant Air, flush water, H₂C₂O₄ or HNO₃, and caustic utility drops are located in the room to support decon activities. A local sump and transfer pump are installed to collect and transfer any spent decon fluids. Decon Area sump discharge can be routed to the ASDT, Drum Off Station, DSSHT, Lab Collection Tanks, or hose connection located in the Truck Bay.

3.8.3 Drum Off Station

A Drum Off Station is located in the Decon Room to allow removal of material from the process systems and sumps. Spent solvent in the CSSX Area is drained to the SDT or pumped from the SHT to the Drum Off Station to allow replacement. Liquid collected in cell sumps that may be incompatible with the process can also be transferred to the Drum Off station. This could include cleaning or decon chemicals, or other miscellaneous materials.

The Drum Off Station receives liquid from the Low Level Drain Tank, Lab Drain Tank, P-110, SHT, SDT, and ASDT. Instrumentation is included in the filling line to monitor the quantities of liquid added to the drum. Temporary enclosures will be installed during drum filling operations to provide shielding and contamination control, as necessary.

3.8.4 Air Dilution System

The Air Dilution System (ADS) is designed to provide sufficient air supply flow to prevent the vapor space of select tanks from approaching the LFL for at least four days after the normal plant air supply is lost. Vessels requiring supply by the ADS are identified in S-SAR-J-00001 (*SWPF Preliminary Documented Safety Analysis*²²). The ADS is a fail-safe, passively actuated system. During normal operation, a continuous supply of Plant Air is fed to the tank vapor spaces and vented to the PVVS. Differential pressure between Plant Air and ADS maintains the dilution air supply. The pressure setpoints for the pressure control valves from the two air sources will minimize the demand on the back-up air receivers during normal operation. On loss of Plant Air, air is supplied from a back-up air storage system. Installed rotameters allow Operations personnel to verify and adjust air flow to the process vessels on an as-required basis.

3.8.5 Pump Seal Supply System

The Pump Seal Supply System provides seal water and air supply pressure to process pump mechanical seals. Process pumps that transfer liquids containing particulates, radioactive material, or aggressive chemicals require double mechanical seals to contain radioactive material and prevent damage to the seal faces. Double mechanical seal systems have a seal pot that maintains a reservoir of seal water and seal supply pressure on the seals. Water is recirculated through the seal pot by action of a pumping ring installed on the pump seal.

The Pump Seal Supply System has a bottled air system supply to maintain pressure on each pump seal pot in excess of the maximum pump discharge pressure for each particular pump. Each seal pot will be equipped with a designated regulator to allow adjustment of the air supply pressure to each pump seal pot as necessary, based on service conditions. Pressure instrumentation is provided to monitor seal pot pressure. Alarms are provided on indication of high or low pressure.

Level indication on the pump seal pots provides indication of seal water supply level. Alarms are provided on high and low levels. If the pump seals are functioning properly and in good condition, seal water usage will be minimal. Water is added manually on indication of low level

in the seal pot. Manual valves are opened by the Operator and the Pump Seal Makeup Water Supply Pump (P-326) is used to supply water to each seal pot.

3.9 Physical Properties

3.9.1 Physical Property Data for SWPF Design

Physical property data of liquid waste for SWPF design was determined by reviewing available literature and test information, as documented in Parsons Memorandum Ref. No. 01-700-02041 (“Review of Physical Property Data for SWPF Feed and MST/Sludge Streams”²³). This document summarizes physical property data and provides values to be used for SWPF process design. In some cases, a range is provided based on available literature data. For design purposes, values are chosen based on the range (low or high, as noted) to provide a conservative design result.

The MST/sludge waste is expected to be Newtonian, however for design purpose a small amount of yield stress is assumed in the sludge.. Fluid rheology is assumed as Newtonian.

Waste feed that varies significantly from assumed physical properties may impact facility processing rates. If the feed does not meet the SWPF WAC, actions to allow the receipt and processing of the material and impact on the facility will require evaluation. Depending on the degree and type of variance, the plant will potentially dilute or blend the waste within SWPF vessels or reduce processing rates.

Process Design Physical Property Data

Salt Solution at 5.6M Na (without solids)

Location: SSFT, CSSX, IST, DSSHT

	<u>Nominal</u>	<u>Range</u>	<u>Assumed Value</u>
Density, g/ml	1.25	1.22 – 1.28	1.29 (high)
Viscosity, cP	3.6	2.4 – 4.8	10 for APAs/Cooling Coils 5 for pump calculations (high)
Heat capacity, J/g °C	3.5	3.4 – 3.6	3.5 (nominal)
Thermal conductivity, W/m °K	0.63	0.57 – 0.70	0.63 (nominal)

Salt Solution at 5.6M Na (with minimal solids)

Location: AST-A, AST-B

	<u>Nominal</u>	<u>Range</u>	<u>Assumed Value</u>
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Density, g/ml	1.25	1.22 – 1.28	1.29 (high)
Viscosity, cP	4.9	4.51 – 5.27	10 for APAs/Cooling Coils 25 for pump calculations (high)
Heat capacity, J/g °C	3.5	3.4 – 3.6	3.5 (nominal)
Thermal conductivity, W/m °K	0.63	0.57 – 0.70	0.63 (nominal)

MST/Sludge stream at 5.0 wt%

Location: FFT-A, SSRT

	<u>Nominal</u>	<u>Range</u>	<u>Assumed Value for up to 7 wt%</u>
Density, g/ml	1.25	1.22 – 1.28	1.29 (high)
Viscosity, cP	4.9	4.51 – 5.27	10 for APAs/Cooling Coils 25 for pump calculations (high)
Yield Stress, Pa	< 3.5	< 3.5	5 (high)
Heat capacity, J/g °C	3.5	3.4 – 3.6	3.5 (nominal)
Thermal conductivity, W/m °K	0.63	0.57 – 0.70	0.63 (nominal)

MST stream at 5.0 wt%

Location: FFT-B, MSTT

	<u>Nominal</u>	<u>Range</u>	<u>Assumed Value</u>
Density, g/ml	1.25	1.22 – 1.28	1.29 (high)
Viscosity, cP	3.6	2.4 – 4.8	10 for APAs/Cooling Coils 25 for pumps (high)
Heat capacity, J/g C	3.5	3.4 – 3.6	3.5 (nominal)
Thermal conductivity, W/m K	0.63	0.57 – 0.70	0.63 (nominal)

3.9.2 Suspended Solids Characterization

Particulate sizing for slurry transport requirements is based on WSRC-TR-2003-00221 (*Particle Size of Simulated SRS Sludge, and Monosodium Titanate²⁴*). This document performs a comparison between actual and simulated waste. Slurry transport requirements are conservatively based on the largest particle size referenced in this document (248µ). Flushing

operations in the SWPF are designed to ensure that the minimum required flow for slurry transport can be achieved. Routine flushing after transfers is performed by using wash water from the WWHT.

APAs for each in-cell vessel will be designed with the capability to achieve a uniform bulk MST/sludge simulant solids concentration. Agitation system design will be based on mixing scale-up models and on test results using, at a minimum, the highest concentration expected in the particular vessel for a given working level. Tank agitation system testing will be performed, using a simulant recipe based on Savannah River Site guidelines. WSRC-TR-2003-00221²⁴ found that the sludge samples, whether simulated or actual, had a median particle size of 2-16 μ and a maximum particle size of 31-248 μ . During normal operation, a completely uniform suspension is not essential to proper operation of any of the in-cell vessels. This design aspect is specified to conservatively design the mixing systems and allow representative sampling of the vessels.

3.10 Materials in Radiation Areas

Materials in Radiation areas will be capable of withstanding the total absorbed doses over the life of the system, or it will be designed to be replaced. The use of Teflon in areas which average 200 Millirem/hour or below (radiation rate calculated assuming feed is at the maximum waste acceptance criteria limit) is allowed. See Table 3-6. Also, the use of Teflon in areas with average radiation fields above 200 Millirem/hour (calculated at maximum waste acceptance criteria limit) may be allowed, but will require written approval from DOE on a case-by-case basis via inclusion in this document. See Table 3-7.

Table 3-6. Rooms where Teflon is allowed.

Room Number	Room Name
R131	N. ASP P&V Gallery Corridor
R131F	North ASP Labyrinth #1
R132A	Contactator Rebuild Area
R133A	Waste Storage Area #1
R135	S. ASP P&V Gallery Corridor
R135C	South ASP Labyrinth #1
R136	CSSX P&V Gallery Corridor
R136A	Sample Pump and Valve Labyrinth
R136F	CSSX Labyrinth #4
R136G	CSSX Labyrinth #3
R137	CSSX Tank Cell Airlock
R140	DSSHT/FFT-B Area Platform
R141	DSSHT/FFT-B Area
R142	IST/AST-B Area
R145	AFF AHU Room
R146	AFF HEPA Filter Room
R203	Process Building Exhaust HEPA Filter Room

Room Number	Room Name
R214	Cell Inlet Air HEPA Filter Room #2
R215	South Utility Chase
R216A	Contactors Support Floor Chase
R253	West Utility Chase
R302	PVVS/PMVS and Laboratory Vent Room
R302A	PVVS/PMVS and Laboratory Vent Room
R303	Cell Inlet Air HEPA Filter Room #1
R304	Laboratory Hot Cell Exhaust Room

Table 3-7. Sprinklers with Teflon are acceptable for use in the rooms listed below.

Room Number	Room Name
R131A	North ASP Labyrinth #6
R131E	North ASP Labyrinth #2
R135A	South ASP Labyrinth #3
R135B	South ASP Labyrinth #2
R136C	CSSX Labyrinth #1
R136D	CSSX Labyrinth # 6
R136E	CSSX Labyrinth # 5
R138	West CSSX Tank Cell
R204	HVAC Shielding Chase
R252	Contactors Operating Deck
R320	Hot Cells

4.0 REFERENCES

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- ⁴ P-SWPF-03-1517, "Assumptions for SWPF Availability and DWPF Outages". Minutes of meeting between J. Kasper (Parsons) and B. Brasel (DOE) on August 14, 2003.
- ⁵ 719004/1, *Parsons Preliminary Test Report: Caustic-side Solvent Extraction (CSSX) Pilot-scale Test (PST)*, in support of the Salt Waste Processing Facility Project. Parsons, Aiken, South Carolina. November 2003.

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