11.0 PLANT SYSTEMS

11.2 AQUEOUS POLISHING PROCESS AND CHEMISTRY

11.2.1 CONDUCT OF REVIEW

This section of the Draft Safety Evaluation Report (DSER) contains the staff's review of the Aqueous Polishing (AP) Process safety described by the applicant in Chapter 11.3 of the Construction Authorization Request (CAR) (Reference 11.2.4.4), with supporting process safety information from Chapters 5, 8, and 11 of the CAR. The objective of this review is to determine whether the chemical process safety principal structures, systems, and components (PSSCs) and their design bases identified by the applicant provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. The staff evaluated the information provided by the applicant for chemical process safety by reviewing Chapter 8 of the CAR, other sections of the CAR, supplementary information provided by the applicant, and relevant documents available at the applicant's offices but not submitted by the applicant. The staff also reviewed technical literature as necessary to understand the process and safety requirements. The review of AP safety design bases and strategies was closely coordinated with the review of the radiation and chemical safety aspects of accident sequences described in the Safety Assessment of the Design Bases (see Chapter 5.0 of this DSER), the review of fire safety aspects (see Chapter 7.0 of this DSER), and the review of plant systems (see Chapter 11.0 of this DSER).

The staff reviewed how aqueous polishing process and chemistry information in the CAR addresses or relates to the following regulations:

- Section 70.23(b) of 10 CFR states, as a prerequisite to construction approval, that the design bases of the PSSCs and the quality assurance program be found to provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents.

- Section 70.64 of 10 CFR requires that baseline design criteria (BDC) and defense-in-depth practices be incorporated into the design new facilities or new processes at existing facilities. With respect to the AP process and related chemistry issues, 10 CFR 70.64(a)(3) requires that the MFFF design "provide for adequate protection against fires and explosions." 10 CFR 70.64(a)(5) requires that the MFFF design provide for adequate protection against "chemical risks from licensed material, and hazardous chemicals produced from licensed material."

The review for this construction approval focused on the design basis of chemical process safety systems, their components, and other related information. For each chemical process safety system, the staff reviewed information provided by the applicant for the safety function, system description, and safety analysis. The review also encompassed proposed design basis considerations such as redundancy, independence, reliability, and quality. The staff used , Chapter 8.0 of NUREG-1718, "Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility," as guidance in performing the review (Reference 11.2.4.6).

At U.S. Nuclear Regulatory Commission (NRC) licensed facilities, as stated in the. "Memorandum of Understanding between the Nuclear Regulatory Commission and the Occupational Safety and Health Administration: Worker Protection at NRC-licensed Facilities," (Federal Register. Vol. 53, No. 210, October 31, 1998, pp. 43950-43951), the NRC oversees chemical safety issues related to (1) radiation risk produced by radioactive materials; (2) chemical risk produced by radioactive materials; and (3) plant conditions that affect the safety and safe handling of radioactive materials, and, thus, represent an increased radiation risk to workers. The NRC does not oversee facility conditions that result in an occupational risk but do not affect the safe use of licensed radioactive material.

The NRC staff reviewed the CAR submitted by the applicant for the following areas applicable to process safety at the construction approval stage and consistent with the level of design (NUREG-1718, page 8.0-8):

- AP Description.
- Hazardous Chemicals and Potential Interactions Affecting Licensed Materials.
- AP Chemical Accident Sequences.
- AP Chemical Accident Consequences.
- AP Safety Controls.

Additional documentation from the applicant and the literature was reviewed as necessary to understand the process and safety requirements. In addition, the CAR incorporates the BDC of 10 CFR 70.64(a) into the design and operations of the proposed facility (see CAR, page 5.5-53), and applicable sections of the CAR are intended to demonstrate compliance with these BDCs.

The staff utilized the guidance provided by Chapter 8.4 of NUREG-1718 for assistance in reviewing the CAR with respect to the chemistry and chemical engineering aspects of the AP process. A summary of the staff's evaluation of the chemistry and chemical engineering design bases of the PSSCs in the AP process is as follows:

- With respect to the electrolyzer, the applicant has not provided sufficient justification for protecting the electrolyzer against the overtemperature event. This applies to the dissolution and silver recovery units (DSER Section 11.2.1.2).

- With respect to the electrolyzer, the applicant's hazard and accident analysis did not consider fires and/or explosions caused by ignition of flammable gases generated by chemical reactions and or electrolysis, such as from an overvoltage condition. This applies to the dissolution and silver recovery units (DSER Section 11.2.1.2 and 11.2.1.10).

- The applicant's hazard and accident analysis did not did not include events involving titanium, such as titanium fires. Accident events should be evaluated and PSSCs identified as necessary. This applies to the dissolution and silver recovery units (DSER Section 11.2.1.2 and 11.2.1.10)

- The design basis value of the corrosion function of the fluid transport system PSSC should address instrumentation and/or monitoring of lower alloy components (stainless steel) that could be exposed to aggressive species (silver II) in the dissolution and silver recovery units (DSER Section 11.2.1.2 and 11.2.1.10).

- The applicant has not proposed a safety strategy, and any needed PSSCs and design bases, for hazardous chemical releases resulting from the potential loss of confinement of radioactive materials in process cells. This affects the dissolver, oxalic precipitation and oxidation, acid recovery, oxalic mother liquor, silver recovery, and liquid waste reception units (DSER Section 11.2.1.2).

- Confirm that the wastes generated will conform to the SRS WACs and that SRS will accept these wastes, based on the program redirection (DSER Section 11.2.1.12).

- The applicant identified the high alpha waste system as an IROFS. The staff finds that the applicant should identify design basis safety functions and values for this unit (DSER Section 11.2.1.12).

- Parameters have not been identified for the plutonium feed to the facility. PSSCs and design bases should be identified for this feed material or a justification provided that it is not necessary (DSER Section 11.2.1.1).

- A design basis and PSSCs are needed for flammable gases and vapors in the Offgas unit (DSER Section 11.2.1.11).

- A design basis and PSSCs are needed for maintaining temperatures below the solvent flashpoint (DSER Section 11.2.1.11).

- Provide a design basis and PSSCs for removal of potentially toxic or reactive gases in the Offgas unit (DSER Section 11.2.1.11).

- The design basis values of the corrosion function of the fluid transport system PSSC should address instrumentation and/or monitoring of components that could be exposed to aggressive species in the Offgas unit (DSER Section 11.2.1.11).

- Identify any PSSCs and design bases for the waste unit, such as maximum inventories (DSER Section 11.2.1.12).

- Provide PSSC and design basis information on the sampling systems (DSER Section 11.2.1.13).

The staff’s detailed evaluation of the proposed AP process is presented in the sections that follow.

11.2.1.1 System Description of the AP Process

This section provides a description and overview of the AP Process, including design, operational, and process flow information. This information is provided to support the hazard and accident analysis provided in CAR Chapter 5, as well as to assist in understanding the overall design and function of the mixed oxide (MOX) Process.

The AP chemistry and chemical engineering information in the CAR, along with supplementary chemistry and chemical engineering information provided by the applicant, especially information provided in response to RAI 111 (Reference 11.2.4.1), was reviewed by the staff. As noted in the CAR and in this DSER, the applicant described the process chemistry in different documents and sections of the CAR. A summary is provided here, broken down by the major process unit operations. Figure 8-1 provides a summary diagram of the AP process.

The design of the AP process is as similar as practical to the proven design currently employed at La Hague's Plutonium Finishing Facilities. Departures from the La Hague design result from United States regulatory requirements, lessons learned at La Hague, or manufacturing and throughput requirements specific to the Mixed Oxide Fuel Fabrication Facility (MFFF). The AP process is designed to receive weapons-grade plutonium from the proposed pit disassembly and conversion facility (PDCF) at Savannah River Site (SRS) and to remove the impurities from the feed plutonium from the PDCF for use in the MP process. The plutonium isotopic composition is identified by the applicant as follows:

- ^{236}Pu < 1 ppb, at the origin of pit
- ^{238}Pu < 0.05 percent
- 90 percent < ^{239}Pu < 95 percent
- 5 percent < ^{24O}Pu < 9 percent
- ^{241}Pu < 1 percent during lifetime of plant
- ^{242}Pu < 0.1 percent.

In the CAR, the applicant has identified the impurities. The feed chemical impurities are listed in DSER Table 11.2-1, and the radionuclide impurities are listed in DSER Table 11.2-2.

In addition, the americium content is as follows:

$$\frac{^{241}\mathrm{Am}}{\mathrm{Pu\ total} + {}^{241}\mathrm{Am}} \qquad <0.7 \text{ percent during the lifetime of the plant}$$

The feed PuO_2 powder has a maximum density of less than 7 g/cc (nominal density of 4.5 g/cc), a moisture content of less than 0.5 percent (reabsorption capability of less than 3 percent), and a maximum particle size of less than 200 microns (minimum particle size greater than 5 microns). The NRC staff noted that these parameters and the values listed in Tables 11.2-1 and 11.2-2 for the plutonium feed to the facility may affect the design and the safe operation of the facility. However, the applicant has stated that there are no design bases for the plutonium feed to the facility (Reference 11.2.4.1, RAI 50). The applicant should either state where these parameters are design bases for specific PSSCs throughout the plant or justify why they are not.

11.2.1.2 Dissolver Chemistry and Reactions (Unit KDB)

The function of the Dissolution Unit is to dissolve the PuO_2 powder. The PuO_2 is electrolytically dissolved in the Dissolution Unit as a precursor for separating impurities (specifically americium, gallium, and uranium) in the Purification Cycle. The powder from a hopper is gradually fed into the electrolyzer by a screw conveyor. Samples from the dilution and sampling tank are analyzed to determine the fissile material content and the required degree of dilution before being sent to the Purification Cycle feed tank. The Dissolution Unit processes approximately 26 lb (12 kg) of plutonium per batch.

The Dissolution Unit consists of two identical processing lines. A cadmium-lined hopper and screw conveyors are installed on scales in a glovebox. The PuO_2 powder is fed into the hopper. The total and the differential weights per unit of time are continuously recorded. The instantaneous flow is computed and compared with the setpoint, and the flow rate is calibrated by the speed of the screw. PuO_2 powder dissolves slowly in a purely nitric medium. Stabilized (calcined) PuO_2 dissolves more slowly than PuO_2 produced at lower temperatures.

Table 11.2-1: Chemical Impurities in the Feed Plutonium Dioxide

Chemical Component	Maximum Content, micrograms/g Pu	Maximum Exceptional Content, micrograms/g Pu	Chemical Component	Maximum Content, micrograms/g Pu	Maximum Exceptional Content, micrograms/g Pu
Ag	NA	10,000	Mg	500	10,000
Al	150	10,000	Mn	100	10,000
B	100	1,000	Mo	100	1,000
Be	100	10,000	N	400	400
Bi	100	1,000	Na	300	10,000
C	500	1,500	Nb	100	10,000
Ca	500	10,000	Ni	200	10,000
Cd	10	1,000	P	200	1,000
Cl	(Cl+F) < 250	500	Pb	200	1,000
Co	100	10,000	S	250	1,000
Cr	100	250	Si	200	200
Cu	100	500	Sm	2	1,000
Dy	1	1,000	Sn	100	10,000
Eu	1	1,000	Ti	100	10,000
F	(Cl+F) < 250	350	Th	100	100
Fe	500	1,000	V	300	10,000
Ga	12,000	12,500	W	200	10,000
Gd	3	1,000	Zn	100	1,000
In	20	1,000	Zr	50	1,000
K	150	10,000	Boron Equivalent	NA	
Li	400	10,000	Total Impurities	18,800	

NA = Not applicable or not available
Maximum Exceptional Value means the maximum anticipated value for that element, with all others at the maximum value.

The dissolution kinetics are improved by augmenting the reaction with a strong oxidizing agent; in this case, by electrolytic dissolution with Ag^{2+}. Silver ions (Ag[II]) are electrolytically produced in a cylindrical compartment. The electrolytic dissolution takes place in a 6N nitric acid solution at 86°F (30°C). The general dissolution process may be described as:

Electrolytic production of Ag^{2+}:

$$Ag^{+} = Ag^{2+} + e^{-} \qquad (11.2\text{-}1)$$

Table 11.2-2: Radionuclide Impurities in the Feed Plutonium Dioxide

Impurity	Isotope	Maximum Content micrograms/g Pu
Americium	Am-241: 100%	7,000 (Note 1)
Uranium (HEU)	U-235: 93.2%	Standard value: 5,000 Maximum value: 20,000 for 10% of the delivered cans during one year Annual maximum quantity = 17 kg.(Note 2)
Note 1: At the plutonium design basis feed rate of 3.5 MTHM/yr, the americium annual quantity becomes 24.5 kg/yr. Note 2: The uranium standard maximum value corresponds to 17.5 kg/yr, while 10% at 20,000 and 90% at 5,000 [micrograms U/g Pu) correspond to 22.75 kg/yr.		

Dissolution of PuO_2 powder:

PuO_2 (solid) + Ag^{2+} = PuO_2^+ (solid) + Ag^+ (11.2-2)
PuO_2^+ (solid) + HNO_3 = PuO_2^+ (solution) (11.2-3)
PuO_2^+ (solution) + Ag^{2+} = PuO_2^{2+} (solution) + Ag^+ (11.2-4)

This gives the following general reaction:

PuO_2 (solid) + $2Ag^{2+}$ = $(PuO_2)^{2+}$ (solution) + $2Ag^+$ (11.2-5)

Ag^+ ions are oxidized at the anode. The staff review notes that electrolytic dissolution of the plutonium dioxide is indirect; electrolysis produces silver(II) which affects the actual dissolution of the plutonium dioxide. If a sufficient concentration of silver is not available, other anode reactions might occur, such as the production of oxygen. This may have safety concerns. For example, the presence of oxygen can lead to explosions with hydrogen. The following reduction reaction takes place at the cathode:

$NO_3^- + 3H^+ + 2e^- = HNO_2 + H_2O$ (11.2-6)

Hydrogen generation can also occur at the cathode:

$2\,H^+ + 2\,e^- = H_2$ (11.2-7)

The staff review notes hydrogen generation usually occurs at a low rate at all times. Under off-normal conditions, such as over voltage, hydrogen generation can increase substantially and become the dominant cathode reaction.

Dissolution occurs when a current is applied. The joule effect of the electrical current supplied is attenuated by cooling the anolyte. The staff review notes that electrolytic processes usually operate at 90-95 percent efficiency (i.e., 90-95 percent of the current goes towards the intended reaction) under the best conditions. Side reactions almost invariably occur and likely involve the evolution of gases, such as hydrogen, oxygen, and NOx. At higher and lower electrode voltages, the electrolyzer would operate in a different regime and a higher percentage of the current could produce gas evolution.

The Dissolution Unit is operated in batches. The Dissolution Unit is designed to treat 48.51 lb/day (22 kg/day) of PuO_2. The operating range of the Dissolution Unit is 30.87 lb/week (14 kg/week) PuO_2 (one dissolution per week) to 381.5 lb/week (173 kg/week) PuO_2 (two lines operating at six batches each per week). The nominal flow rate to the Purification Cycle is approximately 3.97 gal/hour (15 L/hr) (min: 0.53 gal/hr [2 L/hr], max: 5.5 gal/hour [21 L/hr]). The staff notes that there appears to be some overlap between the presented plutonium dissolution rates.

The receiving tank within the dissolution unit is used for interim storage. Hydrogen peroxide is added to this tank to adjust the oxidation state of the plutonium from (VI) to (IV); a plutonium(IV) oxidation state allows for better extraction and separations. The peroxide also reduces any excess silver(II) to silver(I). The uranium impurity exists as the U-235 isotope (from radioactive decay of Pu-239 and nonseparable portions of the original pit—essentially >93 percent uranium enrichment or assay). Consequently, an initial isotopic dilution to 30 percent assay is made by adding the appropriate quantity of depleted uranium nitrate solution (0.25 percent U-235) to the receiving tank. Other adjustments (e.g., acidity) may also be made to the solution in the receiving tank as are necessary to optimize subsequent purification of the plutonium.

The electrolyzer is an important component in the MFFF. In its review, the staff could not find a clear delineation of the design bases associated with this component. Only the aforementioned plutonium processing rate is specified and a temperature limit is implied, based upon a potential fire event. The staff requested additional information on the dissolver. The applicant provided supplemental information (Reference 11.2.4.1, RAI 50) that discussed a loss of confinement scenario for the electrolyzer, based upon an over-temperature situation caused by a control system failure, electric isolation failure, or a loss of cooling. This could ultimately result in boiling of the solution and a release of up to 30.8 lb (14 kg) of unpolished plutonium. The applicant concluded that the event must be either prevented or mitigated, and selected a prevention strategy based upon shutdown of the electrolyzer and natural cooling. The applicant identified the safety design basis as the detection of the high temperature (identified as >158^{o}F [70^{o}C]) and shutdown of the electrolyzer and related processes without exceeding any design limits or chemical control limits, using assigned channels on the emergency control system. Shutdown was understood to be termination of the electrical current. The PSSCs identified by the applicant are the temperature and shutdown controls, and the process safety I&C system. The applicant's response further noted that the electrolyzer is geometrically safe to preclude potential criticality events. The applicant mentioned isolation of the anode and cathode and an isolation monitoring system. The applicant also stated the scavenging and emergency air systems would be used to preclude the possibility of explosions, based upon the rate of hydrogen generated by radiolysis. Consequently, the applicant indicated the voltage to the electrolyzer would be limited.

The staff review noted that electrolytically generated hydrogen from over-voltage conditions would likely produce hydrogen concentrations exceeding the lower flammability limit (LFL) if the scavenging air flow is based only upon radiolysis. In addition, over-voltage conditions could produce other undesirable effects such as flow oscillations, sparking, and greater heating.

The NRC expressed concerns about the completeness of the response for the electrolyzer, including the design bases, and assurances of adequate safety. The applicant stated that the single failure criteria applied to this area (Reference 11.2.4.1, RAI 50). In response to NRC questions regarding other potential PSSCs and design bases beyond solution temperature (such as those relating to the plutonium dioxide powder characteristics and flow recirculation rates, silver ion concentrations and bulk versus localized measurements and on the electrical parameters, the applicant responded that there were no other PSSCs for this unit and that particle size did not matter. Additionally, the applicant was not aware of any specific changes to the electrolyzer's design because of lessons-learned from France.

As already noted, the staff review indicates a number of parameters in the CAR and applicant responses (such as voltage/electrical, silver ion concentration(s), and flammable vapor limits) that could be used to avoid fire. The staff also believes the applicant needs to verify that any lessons-learned from experience at facilities in France and chemical process industry practice with electrolyzers have been adequately considered and addressed by the design bases and control strategy. Consequently, the staff concludes the applicant has not provided sufficient justification for protecting the electrolyzer against the overtemperature event in the applicant's hazard and accident analysis.

Also related to the electrolyzer safety, the applicant's hazard and accident analysis did not consider fires and/or explosions caused by ignition of flammable gases generated by chemical reactions and/or electrolysis. The staff notes the discussion about the use of scavenging and emergency air systems to preclude the possibility of explosions, based upon the rate of hydrogen generated by radiolysis. In the response to RAI 122 (Reference 11.2.4.1), the applicant provided supplemental information on the scavenging air flow for "... radiolysis risk mitigation based on the renewal of the atmosphere of the free volume in vessels containing plutonium." A maximum hydrogen concentration of 1 percent is discussed but no design bases are identified. The staff restates the need for a flammable gas design basis explicitly for this unit that incorporates potential unknowns from chemical reactions and electrolysis. The applicant has not provided a safety design basis for the gas spaces in the electrolyzer and the ullage spaces in the dissolution unit. Based on the applicant's hazard and accident analysis, the applicant should provide additional design basis information for flammable gases and vapors around the electrolyzers and associated systems or provide justification that it is not necessary.

The staff evaluation notes that the proposed approach uses oxidation-reduction chemistry based upon the silver (I) to silver(II) couple. Silver(II) is corrosive and special alloys are necessary for the electrolyzer equipment. From RAI response 50 (Reference 11.2.4.1), the applicant intends to use titanium for the electrolyzer circuit and associated equipment that could be exposed to silver(II) ions. The applicant identifies a negligible corrosion rate for titanium in the presence of silver(II) and nitric acid. The applicant intends to destroy silver(II) (i.e., by conversion into silver(I)) prior to the solutions contacting other equipment in the process that are fabricated out of 300 series stainless steels. Destruction would be accomplished by the addition of peroxide, which reduces the silver(II) back to silver(I).

The staff finds that a higher alloy material, such as titanium, is needed for adequate corrosion resistance in the presence of aggressive conditions that are likely to exist in this electrolyzer. However, industry has developed guidelines for use of such alloys, particularly for protection during wet/dry cycling and heating. Titanium exposed to hot sparks can ignite and burn, and there have been incidents of uncontrolled fires in titanium heat exchanger tube bundles. Staff finds that the applicant should address titanium metal fire hazards in the safety assessment. The staff identifies this as an open item. The applicant's hazard and accident analysis did not include events involving titanium, such as titanium fires. Accident events should be evaluated and PSSCs identified, if necessary. This may involve means to monitor local metal temperatures, detect metal fires, avoid overtemperature, avoid sparks, and/or actively quench the metal and components.

Lower alloys can be inadvertently exposed to aggressive conditions; for example, stainless steel would likely experience uneven pitting corrosion that could lead to premature leaks and failures if it is routinely exposed to low concentrations of silver(II) ions. The applicant has proposed a generic corrosion control program as a PSSC. This appears to be based upon general corrosion. The pitting corrosion that could occur from silver(II) ions might not be detected prior to failure by the proposed PSSC of a general corrosion control program, and, thus, the potential exists for the corrosion leak to release plutonium compounds (i.e., a loss of confinement).

In Table 5.5-10 from Section 5.5 of the CAR, the applicant has identified a control strategy for leaks of AP process vessels and pipes in process cells. This control strategy uses the process cell and its associated ventilation system as the PSSC for loss of confinement events. The applicant intends to contain fluid leaks within the cell and any airborne contamination would be treated with HEPA filtration prior to exhaust. The PSSC of Process Cell Entry Controls prevents the entry of personnel into process cells during normal operations and ensures that workers do not receive a dose in excess of limits while performing maintenance. The actual fluid leaks would not be prevented. The staff review has identified a potential event involving an acute chemical exposure to facility and site workers from hazardous chemicals produced from licensed materials that leak from AP process vessels during such a loss of confinement event. Such a leak could occur due to erosion/corrosion of the vessels and piping. The leak would consist of radioactive nitrate solutions which, once released from the vessels and pipes, would expose a large liquid surface area that allows a nitric acid and NOx release into the cell's atmosphere. This material would not be removed by the HEPA filters on the exhaust system and would be released to the atmosphere. For 100-200 gallons of radioactive nitrate solutions, TEEL-3 limits would be exceeded for several hundred meters. Some of the solutions might be at temperatures above ambient which could result in TEEL-3 limits being exceeded for larger distances. Thus, the performance requirements of 10 CFR 70.61(b)(4) and 10 CFR 70.61(c)(4) would not be met. The applicant has not identified a control strategy for this event. The staff identifies this as an open issue. The applicant should identify a control strategy for this event, with PSSCs and design bases as necessary, or justify why none are required. At a minimum, this potentially impacts the following units: dissolution, oxalic precipitation and oxidation, oxalic mother liquor, acid recovery, silver recovery, and liquid waste reception.

The staff notes that the applicant has not proposed to prevent leaks in the process cells at this time. Were the applicant to choose a prevention strategy for loss of confinement in process cells, the staff would also be concerned about the potential impact of stray electrical currents from the electrolyzer. In response to NRC RAIs (Reference 11.2.4.1, Numbers 50 and 141), the applicant provided information on an isolation and grounding system. The description of this system implies that it is more focused on leakage from the electrodes to ground; it is not clear that the isolation system would detect small stray currents (i.e., which can accelerate corrosion) and could initiate loss of confinement events.

11.2.1.3 Purification Cycle (Unit KPA)

The main goal of the Purification Cycle is to separate plutonium from impurities contained in the solution coming from the Dissolution Unit. In the CAR, the applicant identified the main functions of the Purification Cycle as follows:

- Receive plutonium nitrate from the Dissolution Unit.
- Perform plutonium extraction and impurities scrubbing.
- Perform plutonium stripping and diluent washing.
- Perform plutonium stripping in plutonium barrier.
- Perform uranium stripping and diluent washing.
- Adjust plutonium to the tetravalent state.
- Receive, control, recycle, and transfer plutonium to the Oxalic Precipitation and Oxidation Unit.
- Wash, control, and transfer raffinates diluent to the Acid Recovery Unit.
- Receive recycled plutonium nitrate from the Oxalic Mother Liquor Recovery Unit.

The Purification Cycle uses a plutonium uranium reduction extraction (PUREX) process and is designed to treat plutonium nitrate at a nominal flow rate of 4 gal/hr (15.1 L/hr), which corresponds to 31.75 lb/day (14.4 kg/day) of plutonium. Plutonium nitrate from the Dissolution Unit is received, and plutonium is extracted and scrubbed for impurities. The plutonium with uranium left in the stream is stripped after adjustment of the plutonium valence to the trivalent state. The Purification Cycle controls plutonium reception, recycle, and transfer to the Oxalic Precipitation and Oxidation Unit. The Purification Cycle also controls the solvent and diluent streams to the Solvent Recovery Cycle and the raffinate stream to the Acid Recovery Unit.

The extraction process is continuous, but the feed solutions from the Dissolution Unit are received in batches. The raffinate and the plutonium nitrate solutions are transferred continuously to the Acid Recovery Unit inlet buffer storage and to the Oxalic Precipitation and Oxidation Unit inlet buffer storage, respectively.

Plutonium nitrate solution is batched to the feed tank for plutonium extraction and impurities scrubbing. Pu(IV) in the aqueous solution (4.5N HNO_3) is extracted by the solvent (30 percent tributyl phosphate (TBP) in branched dodecane) in a pulsed extraction column. The impurities remain primarily in the aqueous phase. The solvent stream is scrubbed by 1.5N nitric acid in a pulsed scrubbing column to ensure good decontamination. The aqueous raffinates are washed by the diluent in a pulsed column and transferred to the raffinate reception tank.

Pu(IV) is reduced to Pu(III) by hydroxylamine nitrate (HAN) ($[NH_3OH^+][NO_3^-]$), and Pu(III) is stripped in a pulsed stripping column (Reaction 11.2-8 and 11.2-9). Hydrazine nitrate is introduced to prevent parasitic reoxidation of Pu(III) back to Pu(IV) (Reactions 11.2-10 and 11.2-11). The stripped plutonium is washed with diluent in a pulsed diluent washing column prior to the final valence adjustment. Unstripped plutonium is extracted in the plutonium barrier mixer-settler bank. Hydroxylamine and hydrazine nitrates are introduced in the last stage of the plutonium barrier. The solvent from the plutonium barrier flows to the uranium-stripping mixer-settler bank.

Plutonium reduction by HAN ($NH_3OH[NO_3]$):

$$2[NH_3OH]^+ + 4Pu^{+4} = 4Pu^{+3} + N_2O(g) + H_2O + 6H^+ \quad (11.2\text{-}8)$$

$$2[NH_3OH]^+ + 2Pu^{+4} = 2Pu^{+3} + N_2(g) + 2H_2O + 4H^+ \quad (11.2\text{-}9)$$

Plutonium reduction by hydrazine:

$$4Pu^{4+} + N_2H_5^+ + H_2O = 4\ Pu^{3+} + N_2O + 5\ H^+ \quad (11.2\text{-}10)$$

Parasitic reoxidation of Pu(III) to Pu(IV):

$$2Pu^{3+} + 2HNO_2 + 3H^+ + NO3^- = 2Pu^{4+} + 3HNO_2 + H_2 \quad (11.2\text{-}11)$$

Uranium is stripped (recovered from the organic phase) in a slightly acidic 0.02N HNO_3 solution in a uranium-stripping, mixer-settler bank. The stripped uranium stream is washed with diluent in a three-stage, diluent-washing, mixer-settler bank. The stripped solvent from the uranium-stripping mixer-settler is directed to the Solvent Recovery Cycle. The aqueous phase from the uranium diluent washing is directed to the Liquid Waste Reception Unit.

The final valence adjustment of Pu(III) to Pu(IV) is achieved by oxidizing the Pu(III) solution with nitrous fumes (essentially a nitrogen dioxide/nitrogen tetroxide mixture). In this process, excess HAN and hydrazine are eliminated, and air stripping of the plutonium solution in an air-stripping column destroys the nitrous acid. The plutonium nitrate solution is received in the plutonium reception tank from where it is transferred to the batch constitution tanks of the Oxalic Precipitation and Oxidation Unit.

The selected aqueous-to-organic ratios in the plutonium extraction and plutonium stripping operations enable the process to obtain a plutonium concentration close to 0.34 lb/gal (40 g/L) at the outlet of the Purification Cycle.

The Purification Cycle operates continuously. The feeding solutions from the Dissolution Unit are received in batches. This cycle is designed to process 30.4 lb/day (13.8 kg/day) of plutonium. The operating range of the Purification Cycle is 24.3 to 42 lb/hr (11 to 19 kg/hr) of plutonium.

The staff concludes that red oil phenomena and HAN reactions apply to this unit however, the applicant has not identified any explicit design bases and PSSCs for this unit. The staff further concludes that the applicant’s hazard and accident analysis is not complete with respect to analyzing red oil phenomena and HAN reactions. See DSER Chapter 8 for discussion of red oil phenomena and HAN reactions and open items. The applicant has committed to providing additional justification for red oil and HAN (Reference 11.2.4.10).

11.2.1.4 Solvent Recovery Cycle (Unit KPB)

In the CAR, the applicant identified the functions of the Solvent Recovery Cycle as follows:

- Recover the used solvent from the Purification Cycle to prevent the accumulation of degradation products.
- Renew the solvent and adjust its tributyl phosphate (TBP) content.
- Store the treated solvent and continuously feed the Purification Cycle.
- Perform a diluent wash operation on the aqueous effluents produced by this operation to remove traces of entrained solvent (note: effluent in this section refers to effluent from individual process units to other process units; the MFFF discharges no radioactive liquid effluent directly to the environment.)

The Solvent Recovery Cycle operates continuously in conjunction with the Purification Cycle. The unit is designed to treat solvents at a nominal flow rate of 4.6 gal/hr (17 L/hr), which corresponds to 31.75 lb/day (14.4 kg/day) of plutonium in the Purification Cycle. Standard PUREX methods are used to wash the solvent and remove the degradation products.

The washed solvent is collected in a buffer tank where it is cooled. The Purification Cycle is continuously fed at a controlled flow rate using a dosing pump. The excess solvent, generated by the diluent wash and the content adjustment TBP wash, is transferred to the Liquid Waste Reception Unit. The aqueous effluents generated by washing undergo a diluent wash in a mixer-settler battery (one stage) at ambient temperature to remove traces of entrained solvent. The aqueous-to-organic phase ratio for this operation is around 100:1.

The diluent is recycled in the mixer-settler with a specific system including an airlift and two pots. The recycling flow rate equals the incoming aqueous flow rate from the mixer-settler bank. The aqueous to organic ratio is close to one when recycling is in operation.

The Solvent Recovery Cycle operates continuously in conjunction with the Purification Cycle. The unit is designed to treat solvents at a flow rate of 4.5 gal/hr (17 L/hr), which corresponds to 30.4 lb/day (13.8 kg/day) of plutonium.

The staff concludes that red oil phenomena and HAN reactions apply to this unit, however, the applicant has not explicitly identified any design bases and PSSCs associated with this unit. The staff further concludes that the applicant's hazard and accident analysis is not complete with respect to analyzing red oil phenomena and HAN reactions. See DSER Chapter 8 for discussion of red oil phenomena and HAN reactions and open items. The applicant has committed to providing additional justification for red oil and HAN (Reference 11.2.4.10) .

11.2.1.5 Oxalic Precipitation and Oxidation Chemistry (Unit KCA)

In the CAR, the applicant identified the functions of the Oxalic Precipitation and Oxidation Unit as follows:

- Receive purified plutonium nitrate concentrated to approximately 0.34 lb/gal (40 g/L) (maximum is 0.38 lb/gal [45 g/L]) from the Purification Cycle and prepare uniform batches.

- Precipitate out the plutonium nitrate as oxalate.

- Produce PuO_2 after filtering, drying, and calcining the oxalate. The filtering operation includes drawing off the mother liquors, washing, and dewatering the plutonium oxalate cake.

- Transfer the PuO_2 to the Homogenization Unit, and transfer the mother liquors and the filter washing solutions to the Oxalic Mother Liquor Recovery Unit.

The precipitation reaction is:

$$Pu(NO_3)_4 + 2\ H_2C_2O_4 = Pu(C_2O_4)_2\ (s) + 4\ HNO_3 \qquad (11.2\text{-}12)$$

The conversion line is rated for the processing of 55.6 lb/day (25.2 kg/day) of plutonium. Plutonium nitrate solutions arrive from the Purification Cycle where acidity and valency are adjusted. They are received in alternate batches in two annular tanks to form a batch with a volume of 21.2 ft3 (0.6 m3). Solutions are transferred by a pump to two dosing wheels, which supply one precipitator each. The solutions flow by gravity from the dosing wheels to the precipitators.

Precipitation takes place in two precipitators which are connected in parallel. The oxalate reagents are injected into each precipitator. The plutonium oxalate precipitate carried by the mother liquors escapes via the precipitator overflows and flows by gravity to a rotary filter. Rotation ensures that dewatering and cake removal are continuously performed. The filter removes the plutonium oxalate cake, plate by plate, with a scraper. The removed cake is collected by a screw mechanism and falls into a chute. It enters the next processing operation (the calcination furnace) by gravity.

The furnace consists of two main parts: a drying zone where the plutonium oxalate is dried, and a calcining zone where the oxalate is transformed into PuO_2 in an oxidizing atmosphere of oxygen. The reaction is:

$$Pu(C_2O_4)_2 + O_2 = PuO_2 + 4\ CO_2 \qquad (11.2\text{-}13)$$

The furnace uses electrical heating in the drying zone and the calcining zone. Thermocouples are used to measure the temperature profile in the furnace. The temperatures of the drying and calcining zones are regulated independently. The speed of rotation of the screw is adjusted manually to maintain the required residence time in the calcining zone. The gases (air, steam, CO_2, and O_2) are routed to the furnace offgas system (described below).

The oxalic mother liquors, which are collected in separator pots, flow by gravity to the Oxalic Mother Liquor Recovery Unit. The filtered mother liquors are adjusted to approximately 3.3N with recovered 13.6N nitric acid to avoid any risk of precipitation of plutonium oxalate caused by residual oxalic acid.

The gases produced during drying and calcination of the plutonium oxalate (CO_2 and steam), the excess of oxygen, and the air from upstream and downstream of the process are removed by a negative-pressure circuit comprising a filter, a condenser, a demister, an electric heater, two high efficiency particulate air (HEPA) filters, and two fans. Gas is extracted from the drying section of the furnace.

Oxalic precipitation and oxidation equipment is designed to polish 2.205 lb/hr (1 kg/hr) of plutonium (i.e., 52.9 lb/day [24 kg/day] of plutonium). The operating range of the Oxalic Precipitation and Oxidation Unit is 0 to 2.75 lb/hr (1.25 kg/hr) of plutonium.

The applicant has identified six categories of hazard events associated with this unit. The types of events postulated in this unit include fire, explosion, loss of confinement, external exposure, load handling and criticality. The safety strategy, including the PSSCs and design basis safety functions for controlling events within these categories, is discussed in DSER Section 5.

The staff evaluated the applicant's safety strategy for hazards within this unit and has three findings; two related to the applicant's assessment of loss-of-confinement events and one pertaining to the applicant's assessment of the red oil hazard.

The staff notes that the applicant's description mentions acidification of the residual mother liquors to avoid the precipitation and unanticipated accumulation of residual plutonium by the oxalate. This indicates a potential a safety function (i.e., avoid plutonium precipitation and potentially related accident scenarios, such as erosion or plugging that could lead to loss of confinement). The staff notes that the applicant is not relying on concentration control to prevent a nuclear criticality in this unit. The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item.

In addition, the staff notes the calciner uses oxygen. The applicant has committed to standards (see CAR, Section 11.9.4, Reference 11.2.4.4) for oxygen use and furnace applications. However, the calciner is likely to include components, such as bearings and seals, that have requirements to maintain their integrity. These components may be adversely affected and lose confinement integrity if operated at above ambient temperatures in the presence of air or oxygen. The applicant has identified nitrogen cooling of the calciner bearings as a means to protect them, presumably from the oxygen-rich environment, but has not identified this as a safety function. The issue of whether the nitrogen system is a PSSC because of its bearing cooling function has been identified as an open item in DSER Section 11.9. The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item.

As discussed in DSER Section 8, a red oil phenomena involving a calcining furnace was reported by Savannah River Site (SRS). This unit includes a calcining furnace that will process materials similar to those processed at SRS. However, the applicant did not identify a red oil hazard in this unit. Therefore, the staff concludes that the applicant should address red oil phenomena in the safety assessment of the design bases for this unit. The applicant has committed to providing additional justification for their safety strategy for the red oil hazard (Reference 11.2.4.10).

11.2.1.6 Homogenization Area (Unit KCB)

In the CAR, the applicant identifies the functions of the Homogenization Unit as follows:

- Receive and homogenize the PuO_2 produced in the Oxalic Precipitation and Oxidation Unit.
- Fill cans with PuO_2 in such a manner that the mass of plutonium per can is constant.
- Prepare samples for laboratory analysis to characterize the batch.
- Perform sample-based residual moisture measurement.
- Perform thermogravimetry analysis.
- Store reference samples.

The unit is designed for flow rates corresponding to 55.6 lb/day (25.2 kg/day) of plutonium. The PuO_2 produced in the Oxalic Precipitation and Oxidation Unit is continuously fed by gravity from the calcination furnace into one of the two separating hoppers installed in parallel. These hoppers are stirred and weighed. One hopper is filled while the other is mixed or emptied. The hopper system packs the oxide in individual recyclable stainless steel cans. The plutonium material balance is determined by weighing the filled cans (Canning Unit) and by determination of the plutonium content of the hopper by powder sampling. Sampling ensures that all the finished product specifications are met in each batch of PuO_2 in each hopper and checks the isotopic composition of the PuO_2 for the finished product of each batch in each hopper. Each sample is divided in a special fractionation glovebox at the boundary of the Homogenization Unit for the purposes of the laboratory. Reference samples are kept in an archiving can in the Homogenization Unit.

The Homogenization Unit operates continuously. Each separating hopper has a maximum useful capacity of about 44.1 lb (20 kg) of PuO_2. In nominal operating process conditions, the plutonium mass inlet flow is approximately 2.3 lb/hr (1.05 kg/hr) of plutonium, which corresponds to 2.6 lb/hr (1.2 kg/hr) of PuO_2. The average output is approximately 50 cans of PuO_2 per week, each containing 5.3 lb (2.4 kg) of PuO_2.

The staff concludes that the applicant has properly identified hazards and controls for this unit.

11.2.1.7 Canning Unit (KCC)

The Canning Unit is designed to package PuO_2 powder in reusable stainless steel cans and transfer them one by one to the MP PuO_2 Buffer Storage Unit to prepare the MOX powder. It is also used to establish the PuO_2 powder material balance. The nominal capacity is about 10 cans of PuO_2 per day, each filled with approximately 5.3 lb (2.4 kg) of PuO_2. The PuO_2 powder is gravity-fed from the homogenizer at a temperature not exceeding 302°F (150°C). Full PuO_2 cans are transferred pneumatically in a shuffle to the MP PuO_2 Buffer Storage Unit. Cans that are discarded due to overfilling (as indicated by weighing) or unsatisfactory laboratory results are transferred to the appropriate upstream process. The nominal flow rates are as follows:

- PuO_2 inlet from the Homogenization Unit: 2.6 lb/hr (1.2 kg/hr).

- PuO_2 outlet: approximately 10 full reusable cans per day.

The staff concludes that the applicant has properly identified hazards and controls for this unit.

11.2.1.8 Oxalic Mother Liquor Recovery (Unit KCD)

In the CAR, the applicant identified the functions of the Oxalic Mother Liquor Recovery Unit as follows:

- Continuously receive oxalic acid mother liquors adjusted to 3.3 N with nitric acid from the Oxalic Precipitation and Oxidation Unit.
- Continuously receive ventilation effluent droplets from the oxidation and degassing columns.
- Concentrate the oxalic mother liquors in a subcritical evaporator to destroy the oxalic acid and purify the overhead product.
- Check and transfer the overhead to the Acid Recovery Unit.
- Monitor and recycle, at a controlled rate, the concentrates to the top of the Purification Cycle.

The nominal capacity corresponds to the processing of the materials generated by the precipitation of 52.9 lb/day (24 kg (HM)/day) plutonium. This translates into a liquor flow rate of around 66 gal/hr (250 l/hour). The Oxalic Acid Mother Liquor Recovery Unit operates continuously, unlike the Oxalic Acid Precipitation and Oxidation Unit which produces the oxalic mother liquors. Consequently, the design includes buffer tanks with more than three days capacity. This allows independent operation of the two units. The mother liquor solution flows by gravity into the buffer tanks (two tanks, about 1 m^3 each). After sampling for plutonium concentration, an airlift transfers the solution into a feed tank (also a 1 m^3 capacity). These tanks have a geometrically safe, annular design. A double airlift transfers the solution from the feed tank into an evaporator. The evaporator concentrates the liquor and generates a relatively clean overhead product (distillate). In the evaporator, residual plutonium oxalate is converted into plutonium nitrate and oxalic acid. In the presence of manganese(II) ions (added as a catalyst) and excess nitric acid, the resulting free oxalic acid decomposes into carbon dioxide, water, and NOx. The reactions are:

$$Pu(C_2O_4)_2 + 4\ HNO_3 = Pu(NO_3)_4 + 2\ H_2C_2O_4 \qquad (11.2\text{-}14)$$

$$H_2C_2O_4 + 2\ HNO_3 = 2\ CO_2 + 2\ NO_2 + 2\ H_2O \qquad (11.2\text{-}15)$$

The evaporator exposes the plutonium nitrate to prolonged boiling (100-135°C) in a highly acidic and oxidizing environment. Consequently, plutonium(IV) and plutonium(III) are oxidized to plutonium(VI) nitrate by reactions such as the following:

$$Pu^{+3} + HNO_3 = Pu^{+4} + NO_2 + OH^- \qquad (11.2\text{-}16)$$

$$3\ Pu^{+4} + 2\ H_2O = 2\ Pu^{+3} + PuO_2^{+2} + 4\ H^+ \qquad (11.2\text{-}17)$$

The distillate is condensed and cooled, and a small percentage is returned to the evaporator/column system to supply reflux via a pot. The net distillate product is analyzed online by x-ray fluorescence for the plutonium concentration. The applicant states in the CAR that, if the concentration is sufficiently low, the distillate is routed to the Acid Recovery Unit. If the plutonium specification is exceeded, the distillate is transferred to the buffer tanks for recycle and retreatment.

The concentrates are removed from the evaporator by an airlift and placed in small buffer tanks. Due to the oxidation reactions, the plutonium is present in the hexavalent oxidation state (as PuO_2^{+2}). The applicant notes in the CAR that, if the residual oxalate concentration meets requirements, then the concentrates are returned to the Purification Unit via an airlift.

Prior experience with evaporators indicates the potential for the unintended accumulation of either solvent or plutonium, or both from changes in system chemistry (Reference 11.2.4.9). Such unintended accumulation can pose three hazards; inadvertent criticality, erosion-corrosion from accumulated solids, and the potential for red oil events.

The applicant has identified six categories of hazard events associated with this unit. The types of events postulated in this unit include fire, explosion, loss of confinement, external exposure, load handling and criticality. The safety strategy, including the PSSCs and design basis safety functions for controlling events within these categories, is discussed in DSER Section 5.

The staff evaluated the applicant's safety strategy for hazards within this unit and has two findings; one related to the applicant's assessment of loss-of-confinement events and one pertaining to the applicant's assessment of the red oil hazard.

The staff notes that the applicant's description mentions acidification of the residual mother liquors to avoid the precipitation and unanticipated accumulation of residual plutonium by the oxalate. This indicates a potential a safety function (i.e., avoid plutonium precipitation and potentially related accident scenarios, such as erosion or plugging that could lead to loss of confinement). The staff notes that the applicant is not relying on concentration control to prevent a nuclear criticality in this unit. The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item. At a minimum, this applies to:

- The distillate product stream.
- The plutonium-containing stream returned to purification.
- The evaporator itself and associated vessels.

The second finding pertains to the applicant's assessment of explosion hazards. As discussed in DSER Section 8, red oil phenomena are associated with evaporators that might contain PUREX processing chemicals. This unit uses an evaporator to concentrate oxalic mother liquors and destroy the oxalic acid. However, the applicant did not identify a red oil hazard in this unit. Therefore, the staff concludes that the applicant should address red oil phenomena in the safety assessment of the design bases for this unit. The applicant has committed to providing additional justification for their safety strategy for the red oil hazard (Reference 11.2.4.10).

11.2.1.9 Acid Recovery Unit (KPC)

In the CAR, the applicant identifies the following functions for this unit:

- Receive extraction raffinates from the Purification Cycle in batches, and continuously receive oxalic mother liquor distillates from the Oxalic Mother Liquor Recovery Unit and active liquid effluents from the Offgas Treatment Unit equipment ventilation.

- Concentrate most of the radioactivity contained in the effluents and send it to the Silver Recovery Unit.

- Recover concentrated acid for recycling in the process.

- Recover distillates from the rectification column.

The unit uses evaporation as the principal treatment method. The nominal capacity corresponds to processing the flows generated by purification of 88.3 ft^3/day (2.5 m^3/day) of liquor. The system is designed to accommodate a nitric acid flow rate of 40.7 gal/hr (154 L/hr). A 88.3 ft^3 (2.5 m^3) feed tank receives the following:

- Raffinates from the Purification Cycle in batches of 53 ft^3 (1.5 m^3).

- Oxalic mother liquor distillates (Oxalic Mother Liquor Recovery Unit evaporator 3000) continuously.

- Recombined acid from the Offgas Treatment Unit.

- Effluents from laboratories in batches.

The solution is transferred from the feed tank by double-stage air lifts and is transferred to the boiler of the first evaporator, a natural recirculation, thermosiphon design. The heating power is kept constant by regulating the steam pressure in the boiler. The concentrates are drained off into a 52.8 gallon (200 liter) tank discontinuously, several times a day. The concentrates contain the americium and gallium impurities and are sent by jet to the Silver Recovery Unit. The overhead product is fed to the second evaporator, which has a similar design and includes a rectification column on the overhead product. The reflux system at top of the column can be used to spray the upper trays and improve decontamination. The recovered acid is drawn off as a concentrate product by airlift and cooled. The acid draw-off flow rate is regulated to maintain the desired acidity. The acid is recycled within the facility. The distillate product is continuously transferred by pump for AP water recycle. Any excess recycle water is analyzed and temporarily stored before being transferred by pump to the Liquid Waste Reception Unit.

The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item.

These evaporators operate on the stream containing americium, uranium, and traces of plutonium. This is essentially a high-alpha contaminated stream and effective decontamination between the concentrates (bottoms products) and the distillate (overheads product) has safety implications. The NRC would anticipate separation requirements and/or specifications for these evaporators and their products. This is related to 10 CFR Part 20 and will be reviewed as part of the review of the license application.

The feed stream to the Acid Recovery unit ultimately comes from the purification cycle and may contain traces of TBP, the solvent, and their (usually nitrated) degradation products. This is the red oil phenomena and is discussed more fully in DSER Section 8.1.2.5.2.5. DOE experience with such streams indicate concerns with autocatalytic reactions, including potential explosions, at higher temperatures. A temperature limit of 135°C is identified. However, as discussed in DSER Chapter 8, the phenomena initiates at lower temperatures and thus, there is clear emphasis in other applications for lower temperatures and additional controls for safety purposes. The staff concludes that red oil phenomena applies to this unit and that the applicant's hazard and accident analysis is not complete with respect to analyzing red oil phenomena. Therefore, the staff concludes that additional PSSCs and their design bases for preventing explosions due to red oil phenomena are necessary for this unit, unless sufficient justification is otherwise provided. See DSER Chapter 8 for discussion of red oil phenomena and open items. The applicant has committed to providing additional justification for red oil (Reference 11.2.4.10).

11.2.1.10 Silver Recovery Unit (KPF)

The Silver Recovery Unit uses electrodeposition to recover silver from the first stage (evaporator) of the Acid Recovery Unit and recycle it into the Dissolution Unit. In the CAR, the applicant identifies the main functions of the Silver Recovery Unit as follows:

- Receive concentrates from the Acid Recovery Unit and deposit the silver they contain on the electrolyzer cathodes.
- Dissolve the silver deposit in recycled nitric acid.
- Analyze the silver concentration of the resulting solution and adjust it if necessary.
- Recycle the recovered silver nitrate to the Dissolution Unit.

In many ways, the silver recovery electrolyzer is similar to the electrolyzers in the dissolution unit.

The Silver Recovery Unit is a batch process and can be operated either in the manual or the automatic mode. Summarizing, the concentrate from the Acid Recovery Unit goes to the electrolyzer. This concentrate also contains the americium and the gallium. The electrolyzer uses several hundred amps to plate the silver on to the cathode, using a solution recirculation mode. After the silver has been plated, the now silver-depleted stream is removed and transferred to the waste treatment unit. A nitric acid solution is introduced to dissolve the silver plate, assisted by reversing the polarity of the electrolyzer. The recovered silver nitrate is recycled to the Dissolution Unit. Reagents are added as needed to improve the electrolysis reactions and efficiencies, and avoid undesirable side products. Stainless steels (300 series) are the principal materials of construction. Some titanium is used for the electrolyzer and its immediate area.

For an electrolyzer batch, a pump recirculates the liquid and ensures solution refreshment between the electrolyzer and a large buffer tank (53 ft^3 [1.5 m^3]). This tank is made of 304L stainless steel and contains the majority of the americium. After silver removal, a separate, smaller buffer tank (52.8-gal (200-L) 304L stainless steel) receives a first batch of silver dissolved in recycled nitric acid and stores the solution while another batch is being processed. The solution is circulated by a pump between the electrolyzer and the small buffer tank for the dissolution of the second silver deposit.

The Silver Recovery Unit is operated in batches. The Silver Recovery Unit is designed to recover 5 kg of silver in one batch. The operating range of this unit is 0 to 84 m^3/hr. The main process flow rates are as follows:

- Large Buffer Tank/electrolyzer recirculation flow rate: approximately 424 ft^3/hr (12 m^3/hr).
- Small Buffer Tank/electrolyzer 2000 recirculation flow rate: approximately 53 gal/hr (200 L/hr).

The electrolyzer performs an important function for the MFFF and operates on a high alpha waste stream. In its review, the staff could not find a clear delineation of the design bases associated with this component and its system. Only the aforementioned recirculation flow rates are specified (the staff notes that the applicant, in response to RAIs 135 and 140 (Reference 11.2.4.1), identified all of the SSCs in the adjacent waste processing area as IROFS). The stream from the silver recovery unit subsequently goes to the waste unit. Thus, the staff would anticipate some SSCs in the silver recovery unit would be designated as PSSCs/IROFS because of similar stream characteristics and safety concerns. The staff concludes more design basis and PSSC information may be needed for construction approval. The staff identified design basis information associated with the electrolyzer and silver recovery unit, such as for the large buffer tank, as an open item. The applicant needs to provide additional design basis information or provide sufficient justification that none are necessary. This information might include flow rates/limits, scavenging air, flammable gas limits, confinement, any chemical additions, and electrical parameters (volt/amp relationships).

As part of the silver recovery process, silver(II) ions may be produced. Silver(II) is corrosive and special alloys are necessary for the electrolyzer equipment. The applicant intends to use titanium for the electrolyzer circuit and associated equipment that could be exposed to silver(II) ions. The applicant identifies a negligible corrosion rate for titanium in the presence of silver(II) and nitric acid. The applicant intends to use hydrogen peroxide to destroy the traces of nitrous acid present that might impede the silver recovery process. Peroxide will also destroy any silver(II) (i.e., by conversion into silver(I)).

The staff finds that a higher alloy material, such as titanium, is needed for adequate corrosion resistance in the presence of aggressive conditions that are likely to exist in this electrolyzer. Refer to the discussion of the safety aspects of this potential hazard in DSER Section 11.2.1.2.

The protection of lower alloys (i.e., stainless steel) that could be inadvertently exposed to the aggressive conditions; for example, stainless steel may result in uneven pitting corrosion that could lead to premature leaks and failures, and loss of confinement of materials. The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item.

The staff notes that the applicant has not proposed to prevent leaks in the process cells at this time. Were the applicant to choose a prevention strategy for loss of confinement in process cells, the staff would also be concerned about the potential impact of stray electrical currents from the electrolyzer. In response to NRC RAIs (Numbers 50 and 141, Reference 11.2.4.1), the applicant provided information on an isolation and grounding system. The description of this system implies that it is more focused on leakage from the electrodes to ground; it is not clear that the isolation system would detect small stray currents (i.e., which can accelerate corrosion) and could initiate loss of confinement events.

11.2.1.11 Offgas Treatment Unit (KWG)

The Offgas Treatment Unit ventilation system is dedicated to vapors and gases from processing equipment. In the CAR, the applicant identifies the functions of this unit as follows:

- Remove plutonium from offgases collected from the Dissolution Unit and from the oxidation and degassing columns (Purification Cycle).
- Recombine the nitrous fumes in a specific NOx scrubbing column.
- Clean, by water scrubbing, the offgases collected from all the AP units.
- Treat the offgas flow by HEPA filtration before release to the stack.
- Maintain negative pressure in the tanks and equipment connected to the process ventilation system.

A specific Offgas Treatment Unit extraction system is dedicated to the pulsed purification columns, with similar functions:

- Treat offgases by HEPA filtration before release to the stack.
- Maintain negative pressure in the pulsation system and the pulsed columns legs.

The NOx-containing offgases (from dissolution/oxidation and degassing columns) are gathered downstream of a cap impactor to remove droplets. The effluent stream collected is recycled, by gravity, to the Oxalic Mother Liquor Recovery Unit. Then, offgases are scrubbed with recycled effluents and with recovered distillates from the Acid Recovery Unit. The offgases then pass through a demister, using an air ejector to provide the motive force. The extraction rate is regulated based upon the pressure in the scrubbing column.

Normal ventilation gases (i.e., process vents) are combined with the treated NOx gas streams. These gases are scrubbed with recycled effluents and then with water. The washed gases successively pass through a cooler, a demister, an electric heater, a double HEPA filtering line (2 x 2), and an exhauster before being released through the stack.

The pulsation air from solvent extraction is treated in a separate (“extraction”) line. The air successively passes through an electric heater, a HEPA filtering line (2 x 2), and an exhauster before being released through the stack.

The Offgas Treatment Unit operates continuously. The NOx scrubbing column is designed to treat approximately 15 to 30 Nm^3/hr. The main ventilation line (offgas scrubbing and filters) is designed to process approximately 250 to 400 Nm^3/hr. The designed capacity of the column pulsation air extraction is 150 Nm^3/hr.

The applicant states that specific operating limits and the associated items relied on for safety (IROFS) will be provided in the integrated safety analysis (ISA).

During its review of the CAR, the staff could only find the following design basis information for this unit (from Section 8.7 of the CAR):

- Ensure venting of vessels/tanks to prevent over-pressurization conditions.
- Provide exhaust to ensure that an explosive buildup of explosive vapors does not occur.
- Provide exhaust to ensure that an explosive buildup of hydrogen does not occur.

The staff finds these to be an identification of design goals rather than the required identification of design bases. References to other sections of the CAR (Sections 11.4 and 11.3.2.11) also did not provide a clear description of the design bases and PSSCs for this offgas unit. The staff would anticipate, for example, design basis for measuring and detecting overpressure, flammable vapors, and hydrogen, and perhaps specific considerations for venting potentially reactive systems (such as red oil and HAN). Specific values would be identified. Consequently, the staff requested additional information. The applicant provided supplemental information (Reference 11.2.4.1, RAI 127) stating there were no additional design bases for this unit. The applicant identified the following additional functions of this unit:

- Continuity of the first confinement barrier.
- Recombination of nitrous fumes (N_2O_4) in a specific NOx scrubbing column.
- Remove, by water scrubbing, acidic gases collected from AP process units.
- HEPA filtration of the offgases (prior to stack release).
- HEPA filtration of offgases from the pulsed purification columns (prior to stack release).
- HEPA filtration of offgases from the calcination furnace (prior to stack release).

The staff also requested information on the “filtering line.” The applicant provided additional information and identified the following design features of the offgas unit (Reference 11.2.4.1, RAI 142):

- Bubbling air scavenges tank ullage to maintain hydrogen concentrations at 1 percent or less.
- The system operates below the flash point of solvent vapors (Reference 11.2.4.1, RAI 126).

- Supplemental air is added to the system to further dilute any potential combustible concentration of gases and to maintain minimum volumetric throughput for the scrubbing and washing columns.

- The material of construction is stainless steel to resist the corrosive atmosphere.

- The HEPA filters are constructed of acid resistant materials.

The staff concludes that red oil phenomena and HAN reactions apply to this unit, however, the applicant has not explicitly identified any design bases and PSSCs for addressing red oil phenomena in this unit. The staff further concludes that the applicant's hazard and accident analysis is not complete with respect to analyzing red oil phenomena and HAN reactions. See DSER Chapter 8 for discussion of red oil phenomena and HAN reactions and open items. The applicant has committed to providing additional justification for red oil and HAN (Reference 11.2.4.10).

The offgas system handles vapors and gas mixtures that are potentially combustible in air streams, such as hydrogen, hydrazine, and dodecane (the solvent). The applicant identifies a 25 percent of the LFL in air for hydrogen in Reference 11.2.4.1, RAI response 142. In RAI response 122, the applicant also identifies a 25 percent of the LFL for hydrogen in air from radiolysis in vessels containing plutonium. The applicant has not identified 25 percent of the LFL for hydrogen as a design bases and has not provided a design basis for other flammable gases and vapors. The staff identified design basis information associated with flammable gases as an open item. The applicant needs to provide additional design basis information for the offgas unit to maintain potentially flammable gases and vapors at safe concentrations below their LFLs at all times, along with PSSCs, or provide sufficient justification that none are necessary.

The staff notes that a 25 percent of the LFL in air limit is routinely used by designers and operating facilities, and is embodied in codes and standards (see Reference 11.2.4.5, Section 5-3.2). Per NFPA 801 (Reference 11.2.4.5), suitable means shall be provided for analyzers, instrumentation, and alarms.

In Reference 11.2.4.1, responses to RAIs 126, 127, and 142, the applicant does not identify temperatures below the flashpoint of solvent vapors. No design bases or PSSCs are identified for the offgas treatment unit. The staff identified design basis information associated with solvent vapor temperature limits in the offgas system as an open item. The applicant needs to provide additional design basis information and any additional PSSCs for the offgas unit in order to maintain the temperature below the flashpoint of solvent vapors at all times, or provide sufficient justification that none are necessary.

The process handles gases and vapors that are potentially reactive and toxic, such as nitrogen tetroxide, nitric acid, NOx, and hydrazine. The unplanned evolution of these gases via the offgas treatment unit could have potentially detrimental consequences that would likely exceed the performance requirements of 10 CFR Part 70 at considerable distances from the proposed facility. In Reference 11.2.4.1, RAI 127, the applicant acknowledges the removal of $N_2 O_4$ and acidic gases as a function of this unit. The response also states the function of continuity of the first confinement barrier. The staff identified design basis information associated with the offgas treatment and removal of potentially toxic and reactive gases as an open item. The applicant needs to provide additional design basis information to provide adequate removal of potentially reactive and toxic gases and maintain the first confinement barrier or provide sufficient justification that none are necessary.

In Reference 11.2.4.1, the applicant's response to RAI 142 mentions the use of stainless steel to resist corrosion in the offgas system and acid resistant materials in the HEPA filters. Corrosion resistant materials would be needed to maintain confinement of radioactive and chemical species. No design basis has been identified by the applicant. The staff concludes a corrosion design basis may be needed. The staff identified design basis information associated with corrosion in the offgas system as an open item. The applicant needs to provide additional design basis information for the offgas treatment unit to address the use of corrosion resistant materials for the materials of construction and the HEPA filters, or provide sufficient justification that none are necessary. The corrosion monitoring program PSSC should also be considered.

HEPA filters are used as the final treatment prior to exhaust up the stack. The design basis for the HEPAs is described in DSER Section 11.4.

11.2.1.12 Liquid Waste Reception Unit (KWD)

The Liquid Waste Reception Unit will receive liquid waste from the AP process for temporary storage before sending it to SRS for treatment and processing. The CAR contains very little description of this unit. In response to RAI 135 (Reference 11.2.4.1), the applicant provided considerable more information on the unit. DSER Table 11.2-3 identifies the high alpha waste sources, the quantities of the waste streams, and the concentrations (or quantities) of the radioactive materials in the streams. DSER Figure 11.2-1 provides a simplified sketch of the high alpha waste system.

Table 11.2-3: Waste Stream Descriptions and Quantities in the Waste Reception Unit

Waste Stream Designation	Maximum Flow Rate, Gal/yea (note 1)r*	Normal Flow Rate, Gal/yr*	Concentration or Annual Quantity (note 2)*
Excess Acid			
Stripped Uranium			
Liquid Americium			
Alkaline Wash			
Total Flow Rates			

Note 1: Maximum flow includes unplanned recycling.
Note 2: Concentrations are based on normal flow rate. Total radioactive material quantities are the same for maximum or normal flow rate. Concentrations based on maximum flow rates would be less.

***Text removed under 10 CFR 2.390.**

The applicant states the alkaline waste stream will be acidified in a separate neutralization tank prior to being mixed with the diluted uranium nitrate in the high alpha waste tanks. Neutralization and acidification is performed to eliminate the potential for an explosion from azide formation that may form under alkaline conditions. In acidic media, the azides have a solubility limit greater than their concentration. Since the solubility limits of azides in alkaline media are lower, the alkaline media is neutralized to increase the solubility limits. This ensures that the azides do not precipitate and create an explosion potential. The staff concludes that the applicant's hazard and accident analysis is not complete with respect to analyzing azide formation and explosion potential. Chapter 8 of the CAR and supplemental information provided by the applicant identified pH control as serving a safety function. However, PSSCs and their design bases for controlling pH have not been identified by the applicant. Therefore, the staff concludes that PSSCs and their design bases for preventing azide formation and explosion potential has not been adequately justified for this unit. See Chapter 8.0 of this DSER for further discussion of azide formation and open items.

The diluted uranium stream, the acidified alkaline stream, and the rest of the high alpha waste is collected in one of two high alpha waste tanks. While one tank is pumped out, the other collects the high alpha waste. The waste is pumped to SRS for storage and treatment using shielded lines. Level inside the tanks is remotely monitored using level instrumentation. The tank contents are sampled prior to start of transfer to SRS to ensure that they comply with the SRS Waste Acceptance Criteria (WAC). It is anticipated that a communications link between the MOX facility and SRS will be used to receive acceptance from SRS to initiate transfers and to signal end of operation at the end of transfer. These communication link issues will be developed during detail engineering. The applicant provided additional information (Reference 11.2.4.2 and 11.2.4.3) that compared the waste to the WACs. Table 11.2-4 provides a summary of the waste streams identified by the applicant in this correspondence. Table 11.2-5 summarizes and compares the MFFF wastes to the SRS WAC requirements. Silver was evaluated and found to be acceptable to SRS in the quantities anticipated; numerical limits were not provided.

The high alpha waste tanks are sized to accommodate a one-week quantity of waste based on 42 operating weeks per year. This corresponds to approximately 1,200 gallons per week. In addition, the tanks are sized to accommodate an equal volume (1,200 gallons) of backwash. Based on a suitable operating margin of 600 gallons, applicant has sized the high alpha buffer tanks at 3,000 gallons. The staff notes that an inventory limit is not specified. The staff further notes that the SRS has limited tank space available for some wastes and SRS acceptance of MFFF waste may require waiting for SRS processing; during such periods, the staff anticipates that active waste generating operations should be curtailed until the potential backlog of waste at the MFFF is cleared. The staff concludes an inventory limit is necessary as a design basis for the unit. The applicant needs to provide additional design basis information or provide sufficient justification that none are necessary. Thus, there are 2 open item associated with this unit as follows:

- Confirm that the wastes generated based on the program redirection will conform to the SRS WAC.

- A maximum inventory of radioactivity and liquids is needed for the waste unit. This will likely be based upon a one week's throughput. If this limit is reached, a commitment is needed from the applicant so that additional dissolution operations and active waste generation will cease until DOE/SRS has accepted the waste backlog and the waste has been transferred to the SRS.

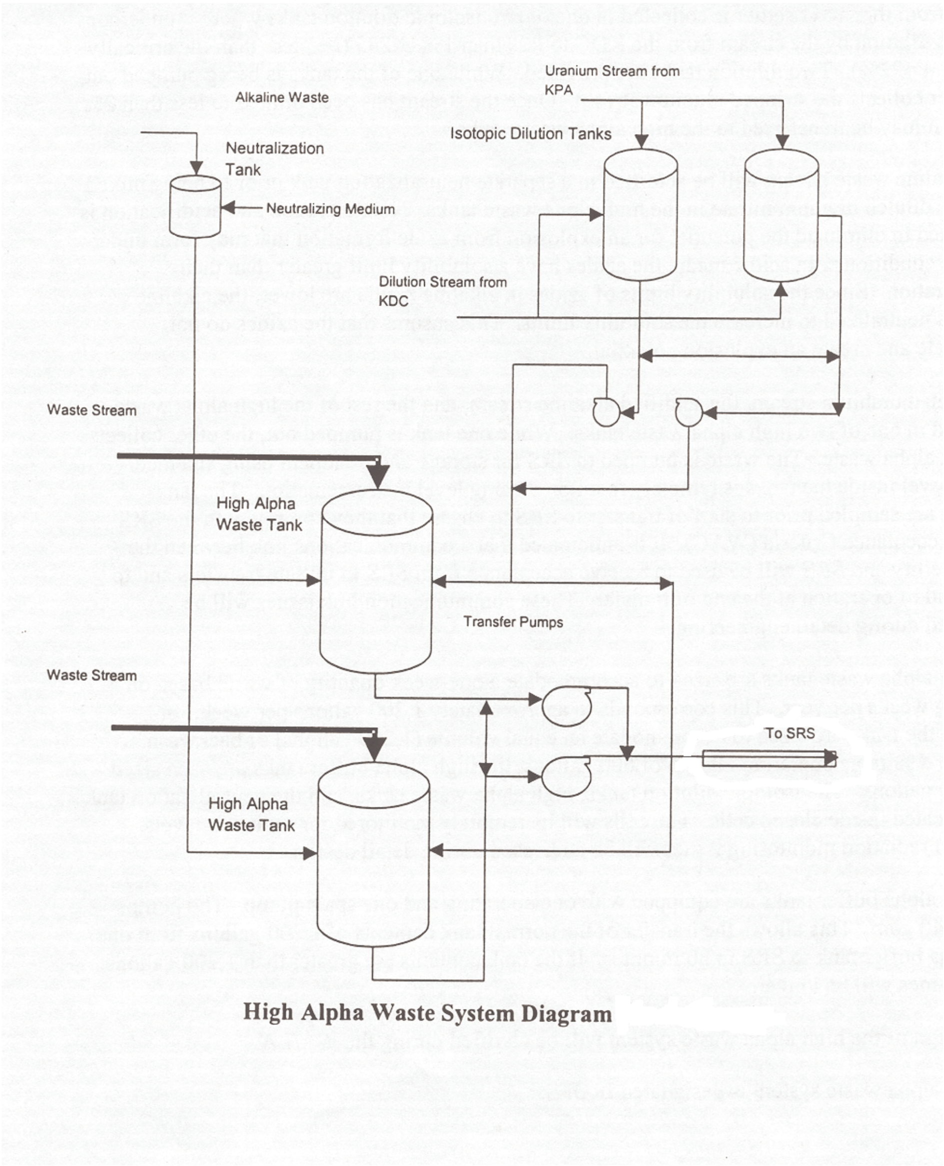
The high alpha buffer tanks are equipped with one operating and one spare pump. The pumps are each 40 gpm. This allows the transfer of the normal tank contents of 1,200 gallons from one high alpha buffer tank to SRS in 30 minutes. If the tank contents are greater than 1,200 gallons, transfer times will be longer.

The applicant has not proposed a control strategy, and any needed PSSCs and design bases, for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. See Section 11.2.1.2 for a description of the open item.

The applicant states the final design of the high alpha waste system will be clarified in its license application (Reference 11.2.4.7). The applicant has designated the high alpha waste system as IROFS (Reference 11.2.4.1, RAI 135). In its review, the staff could not identify the PSSCs associated with the IROFS identified by the applicant and the associated design bases. The staff identified PSSC and design basis information associated with the applicant’s use of the phrase, “The high alpha waste system is designated IROFS,” in the waste system as an open item. The applicant needs to provide additional PSSCs and design basis information or provide sufficient justification that none are necessary.

At the public meeting on February 13, 2002, the applicant provided supplemental information on changes in the proposed MOX program to accommodate alternate feedstock materials (Reference 11.2.4.8). Program changes will likely introduce new constituents into the waste streams. In addition, the applicant indicated a change in the DOE waste management approach at the SRS. DOE now intends to construct new facilities at SRS for handling waste streams from the proposed MOX facilities. No information was currently available on the new waste facility(ies) type, design, capacity, and waste acceptance criteria. The previously identified WACs may no longer apply. The applicant will provide a supplemental CAR and Environmental Report at a later date.

Figure 11.2-1 Simplified sketch of the high alpha waste system



11.2.1.13 Sampling Systems

The sampling system is used for radioactive and chemical solutions. Three liquid sampling system approaches that the applicant intends to use at the MFFF are direct, suction, and remote sampling. In direct sampling, the solution is directly extracted from the process equipment by gravity flow or with a recycling pump into a vial. Direct sampling is limited to nonaggressive reagents or effluents of suspect origin. A large sample volume provides a lower detection limit. In suction sampling, a vial is filled by suction through a needle by the vacuum in the vial. Suction filling can be performed manually or with a moving cask. Aggressive reagents can be sampled manually but with vacuum vial filling. Plugging of the sampling system is not expected because all AP process solutions are expected to be clear (without particles). A moving cask is used for suction filling of active liquids. With remote sampling, the solution is lifted up by an airlift head from which direct vacuum sampling is carried out. For concentrated radioactive liquid waste, remote sampling under a box is required. The applicant has stated that all sampling systems will be qualified using engineering studies and/or evaluations (Reference 11.2.4.4, Section 11.3.2.13).

The staff notes that, for construction, limited information is available beyond the previous discussion as detailed design is ongoing. The applicant provided additional information on the laboratory and planned samples in the response to RAI 223 (Reference 11.2.4.1). The staff believes the outline of the sampling approaches appears to follow typical practices used in the chemical and nuclear industries. Sampling usually involves small quantities of materials, and this is indicated by the list of proposed samples in the response to RAI 223. A total inventory of approximately 200 grams (as PuO_2) is identified by the applicant in Table 5.5-2 of the CAR. However, the applicant has not provided any analysis or estimate to demonstrate that sampling incidents will not challenge the performance requirements. The staff finds that the applicant needs to provide additional design basis information or provide sufficient justification that none are necessary.

Table 11.2-4 Characteristics of MFFF Waste Streams

Waste Stream	Waste Type	Annual Volume (m^3) Expected/Max.	Annual Weight (t) Expected/Max.	Contamination (mg Pu / kg) Expected/Max.	Main Characteristics
TRU Waste					
(solid)	Low Contaminated (organics)	42/51	5.5/6.6	~5	Paper, plastics
	Low Contaminated (miscellaneous)	16/19	3.8/4.6	~5	metals
	Low Contaminated	9/11	3.6/4.4	~10	zirconium clads, molybdenum boats, lab wastes
	Highly Contaminated (organics)	37/45	5.7/6.9	~250	
	Highly Contaminated (miscellaneous)	13/16	3.7/4.5	~250	
	PuO_2 Convenience cans (not compacted)	~5/5	0.9/0.9	~200	
	Dust Catchers 1st barrier filters	~2 / 2.4	~0.1/0.1	~1000	Preliminary estimate
	Other active filters	~7 / 8.4	~0.7/0.9	Up to 100	Rough values
	Other TRU waste	~1/1.2	0.4/0.5	~200	Grinding wheels, U balls, lab wastes, non-compactible
High Alpha Activity Liquid Waste					
(liquid)	Raffinate stream from AP	31.6/37.9			24.5 kg Am-241 (84,000 Ci); Pu<152 g; $[H^+]$=3N; Ga=42kg; Ag=4kg/5kg; NO_3^-=250kg max.
	Stripped Uranium stream	134/161			U=16g/L; Pu<0.1mg/L; $[H^+]$=0.108N; 2,150kg U/yr; U=13.4 g/L max.

Table 11.2-4 Characteristics of MFFF Waste Streams (continued)

Waste Stream	Waste Type	Annual Volume (m^3) Expected/Max.	Annual Weight (t) Expected/Max.	Contamination (mg Pu / kg) Expected/Max.	Main Characteristics
	Alkaline wash stream	9.4/11.28			Pu<13 g/yr; U<13g/yr; Na=96kg / 116 kg max
	Excess Acid	5			$[H^+]$=13.6N; Am-241< 48mCi/yr
	Total High Alpha Activity Waste	180/215.18			
Operating LLW					
(solid)	UO2 area waste (organic)	7/14	0.8/1.6		U contam., mostly incinerable
	Cladding area waste (organics)	8/16	0.9/1.8	<1	mostly incinerable
	Swarf and samples (zirconium)	1/2	~0.2/0.4	<0.2	possible zirconium hazards
	Inner Cans (stainless steel)	Up to 7	1.8	<0.2	Bulk volume
	Building ventilation and U area filters	Up to 20/40	2.8/5.6	<0.3	Bulk volume
	Miscellaneous LLW-non-compatible	0.5/1	~0.1/0.2	<0.2	Assumed non-compactible
	Total Operating LLW	43.5/80	6.6/11.4		
Potentially Contaminated Waste					
(solid)	Incinerable (organics)	204/408	32/64	<0.3	Contamination levels are expected to be below the lower limit of detection
	Non-incinerable (miscellaneous)	27/54	7/14	<0.3	Contamination levels are expected to be below the lower limit of detection
	Total Potentially contaminated waste	231/462	39/78		
LLW					
(liquid)	Distillate	320/384			Am-241<2.9 mCi/yr; [H+]=0.02 N

Table 11.2-4 Characteristics of MFFF Waste Streams (continued)

Waste Stream	Waste Type	Annual Volume (m^3) Expected/Max.	Annual Weight (t) Expected/Max.	Contamination (mg Pu / kg) Expected/Max.	Main Characteristics
	Laboratory Rinsing	100			
	Sanitary Washing	350			
	Room HVAC condensate	50			
	Total Rinsing Water	500/600			<4 Bq alpha/L [0.14 pCi/mL]
Mixed LLW					
(liquid)	Excess solvent (TBP & dodecane)	8.8/10.56			Pu<17.2mg/yr; [H+]=0.007N; alpha=1.4 mCi/yr; beta=1.8 mCi/yr
Non-Hazardous					
(solid)	Non-hazardous solid waste	<440/<880			MOX Process Design Criteria
(liquid)	Non-hazardous liquid waste	6500/7800			MOX Process Design Criteria
Hazardous					
(solid)	O&M	0.1			MOX Process Design Criteria
(liquid)	O&M	1.0			MOX Process Design Criteria

Table 11.2-5 Summary of MFFF Waste Streams and WSRC WAC Requirements

Waste Stream	Waste Type	SRS Destination	WAC Section/ Requirement	MOX Waste Compliance w/WAC
TRU Waste				
(solid)	Low Contaminated (organics)	E-Area TRU Pads	WAC Section 3.06; E-Area, TRU Pads. Must meet WIPP WAC	Waste characteristics: solids>100 nCi/g. No free liquids. Contact handled TRU, dose rate at contact <200 mrem/hr. Packaging in accordance with WIPP (55-gallon drum, WIPP SWB). Data Package, acceptable knowledge. Only toxicity characteristic inorganic RCRA constituents.
	Low Contaminated (miscellaneous)			
	Low Contaminated			
	Highly Contaminated (organics)			
	Highly Contaminated (miscellaneous)			
	PuO2 Convenience cans (not compacted)			
	Dust Catchers 1st barrier filters			
	Other active filters			
	Other TRU waste			
High Alpha Activity Liquid Waste				
(liquid)	Raffinate stream from AP	HLW Tank Farm	WAC Section X-SD-G-0001. No waste containing silver, unless quantity is determined by WSRC to be acceptable	Level of silver in waste stream was evaluated by WSRC to have no impact.
	Stripped Uranium stream	HLW Tank Farm	WAC Section X-SD-G-0001. Waste inherently safe.	Weight ratio of U-238/U-235 of 103
	Alkaline wash stream	HLW Tank Farm	WAC Section X-SD-G-0001. No specific provisions	Meets WAC

Table 11.2-5 Summary of MFFF Waste Streams and WSRC WAC Requirements (continued)

Waste Stream	Waste Type	SRS Destination	WAC Section/ Requirement	MOX Waste Compliance w/WAC
	Excess Acid	HLW Tank Farm	WAC Section X-SD-G-0001. No specific provisions	Meets WAC
Operating LLW				
(solid)	UO2 area waste (organic)	Compaction/Direct Disposal	WAC Section 3.17, Low Level radioactive waste. No explosives, gaseous waste, pyrophoric, shock sensitive, and propellant waste. No PCBs, pathogens, hazardous wastes, pressurized containers, incompatible wastes, asbestos, animal carcasses, freon or petroleum contaminated soil.	Waste Characteristics: solid<100 nCi/g. No free liquids. Packaging in 55-gallon drums, which can be emptied, compacted and placed into B-25 boxes.
	Cladding area waste (organics)	Compaction/Direct Disposal		
	Swarf and samples (zirconium)	Compaction/Direct Disposal		
	Inner Cans (stainless steel)	Compaction/Direct Disposal		
	Building ventilation and U area filters	Compaction/Direct Disposal		
	Miscellaneous LLW-non-compactible	Compaction/Direct Disposal		
Potentially Contaminated Waste				

Table 11.2-5 Summary of MFFF Waste Streams and WSRC WAC Requirements (continued)

Waste Stream	Waste Type	SRS Destination	WAC Section/ Requirement	MOX Waste Compliance w/WAC
(solid)	Incinerable (organics)	Compaction/Direct Disposal	WAC Section 3.17, Low Level Radioactive waste.No explosives, gaseous waste, pyrophoric, shock sensitive, and propellant waste. No PCBs, pathogens, hazardous wastes, pressurized containers, incompatible wastes, asbestos, animal carcasses, freon or petroleum contaminated soil.	Waste Characteristics: solid<100 nCi/g. No free liquids. Packaging in 55-gallon drums, which can be emptied, compacted and placed into B-25 boxes.
	Non-incinerable (miscellaneous)	Compaction/Direct Disposal		
LLW				
(liquid)	Distillate	ETF	WAC Section 4.02, F/H ETF, VOC. Toxic gases, vapors and fumes, listed wastes prohibited. Radionuclide content <100 dpm/mL alpha to the waste water collection tanks	No VOC, toxic gases, vapors and fumes, or listed wastes. Alpha <0.24 dpm/mL.
	Laboratory Rinsing	ETF		
	Sanitary Washing	ETF		
	Room HVAC condensate	ETF		
Mixed LLW				
(liquid)	Excess solvent (TBP & dodecane)	CIF Solvent Storage Tanks/Commercial	WAC Section 3.16, Solvent Storage Tank. Nuclear Safety Criteria <23 g/ 1000 gal fissile gram equivalents (FGE) U-235	FGE=0.007
Non-Hazardous				

Table 11.2-5 Summary of MFFF Waste Streams and WSRC WAC Requirements (continued)

Waste Stream	Waste Type	SRS Destination	WAC Section/ Requirement	MOX Waste Compliance w/WAC
(solid)	Non-hazardous solid waste	Three Rivers Landfill	WAC Section 3.14, Sanitary WAC. 3Q-ECM 6.2 (Environmental Compliance Manual). Green is Clean and clean associated waste	No radioactive contamination present
(liquid)	Non-hazardous liquid waste	Sanitary Sewer	NA	NA
Hazardous				
(solid)	O&M	Haz. Waste Storage Facility	WAC Section 3.18, Hazardous, Mixed and PCB WAC. No TRU waste and No Greater than Class C waste sent to HWSF/MWSF. No added radioactivity allowed at HWSF. Physical/chemical forms compatible. Only specific hazardous waste codes will be transferred	Hazardous and mixed waste storage facilities hold waste for shipment to TSD facility. No TRU waste sent to HWSF/MWSF. Physical/chemical forms compatible. Packaging, labeling and documentation complete per WAC.
(liquid)	O&M			

11.2.2 EVALUATION FINDINGS

In Section 11.2.7 of the CAR, DCS provided design basis information for the AP process that it identified as PSSCs for the MFFF. Based on that the staff's review of the CAR and supporting information provided by the applicant relevant to the AP process, the staff finds that, due to the open items discussed above and listed below, DCS has not met the BDC set forth in 10 CFR 70.64(a)(3), for explosions, and (a)(5), for chemical safety. Further, until the open items are closed, the staff cannot conclude, pursuant to 10 CFR 70.23(b), that the design bases of the PSSCs identified by the applicant will provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents.

The open items are as follows:

- With respect to the electrolyzer, the applicant has not provided sufficient justification for protecting the electrolyzer against the overtemperature event. This applies to the dissolution and silver recovery units (SER Sections 11.2.1.2) (AP-1).

- With respect to the electrolyzer, the applicant's hazard and accident analysis did not consider fires and/or explosions caused by ignition of flammable gases generated by chemical reactions and or electrolysis, such as from an overvoltage condition. This applies to the dissolution and silver recovery units (SER Sections 11.2.1.2 and 11.2.1.10) (AP-2).

- The applicant's hazard and accident analysis did not did not include events involving titanium, such as titanium fires. Accident events should be evaluated and PSSCs identified as necessary. This applies to the dissolution and silver recovery units (SER Sections 11.2.1.2 and 11.2.1.10) (AP-3).

- The design basis value of the corrosion function of the fluid transport system PSSC should address instrumentation and/or monitoring of lower alloy components (stainless steel) that could be exposed to aggressive species (silver II) in the dissolution and silver recovery units (SER Sections 11.2.1.2 and 11.2.1.10) (AP-4).

- Confirm that the wastes generated will conform to the SRS WACs and that SRS will accept these wastes, based on the program redirection (SER Section 11.2.1.12); Identify any PSSCs and design bases for the waste unit, such as maximum inventories (SER Section 11.2.1.12) (AP-5).

- The applicant identified the high alpha waste system as an IROF. The staff finds that the applicant should identify design basis safety functions and values for this unit (SER Section 11.2.1.12) (AP-6).

- Parameters have not been identified for the plutonium feed to the facility. PSSCs and design bases should be identified for this feed material or a justification provided that it is not necessary (SER Section 11.2.1.1) (AP-7).

- A design basis and PSSCs are needed for flammable gases and vapors in the Offgas unit (SER Section 11.2.1.11) (AP-8).

- A design basis and PSSCs are needed for maintaining temperatures below the solvent flashpoint (SER Section 11.2.1.11) (AP-9).

- Provide a design basis and PSSCs for removal of potentially toxic or reactive gases in the Offgas unit (SER Section 11.2.1.11) (AP-10).

- The design basis values of the corrosion function of the fluid transport system PSSC should address instrumentation and/or monitoring of components that could be exposed to aggressive species in the Offgas unit (SER Section 11.2.1.11) (AP-11).

- Provide PSSC and design basis information on the sampling systems (SER Section 11.2.1.13) (AP-12).

- The applicant has not proposed a safety strategy, and any needed PSSCs and design bases, for hazardous chemical releases resulting from the potential loss of confinement of radioactive materials in process cells. This affects the dissolver, oxalic precipitation and oxidation, acid recovery, oxalic mother liquor, silver recovery, and liquid waste reception units (SER Section 11.2.1.2) (AP-13).

DCS has provided additional information concerning open items identified by the staff as AP-1, 2, 3, 4, 5, 6, 7 and has stated that it will provide additional information concerning open items identified by the staff as AP-4, 5, 7, 8, 9, 10, 11, 12 (Reference 11.2.3.10). Because the information was provided recently, the staff has not completed its review.

11.2.4 REFERENCES

11.2.4.1. Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Response to Request for Additional Information, August 31, 2001.

11.2.4.2. Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, January 7, 2002.

11.2.4.3. Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, March 8, 2002.

11.2.4.4. Ihde, R., Duke Cogema Stone & Webster, letter to W. Kane, U.S. Nuclear Regulatory Commission, RE Submitting Request for Authorization of Construction of Mixed Oxide Fuel Fabrication Facility, February 28, 2001.

11.2.4.5 National Fire Protection Association (NFPA). 801, “Standard for Fire Protection for Facilities Handling Radioactive Materials.” NFPA: 1998

11.2.4.6. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-1718, “Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility.” NRC: Washington, D.C. August 2000.

11.2.4.7. Persinko, A., U.S. Nuclear Regulatory Commission (NRC), memorandum to E.J. Leeds, NRC, RE 11/27-29/01 In-Office Review Summary of DCS Construction Authorization Request Supporting Documents for the MFFF, December 18, 2001.

11.2.4.8. Persinko, A., U.S. Nuclear Regulatory Commission (NRC), memorandum to E.J. Leeds, NRC, RE2/13/02 Meeting Summary: MFFF Program Changes and Applicant Reorganization, February 27, 2002

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11.2.4.10 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, April 23, 2002.