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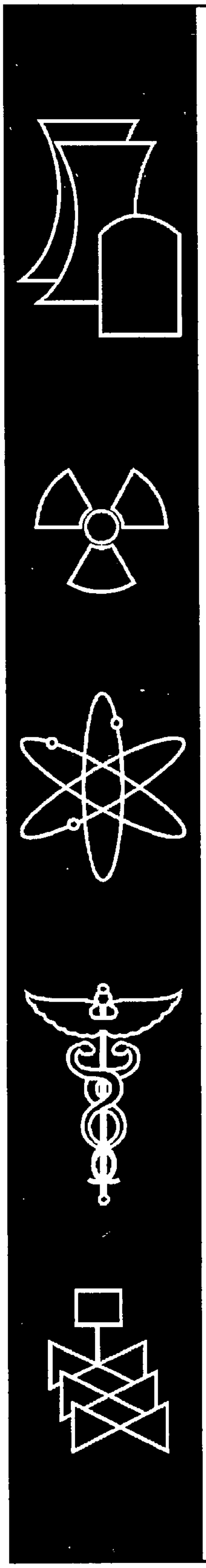

Final Safety Evaluation Report on the Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina

Docket No. 70-3098

Duke Cogema Stone & Webster, L.L.C.

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Division of Fuel Cycle Safety and Safeguards
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11.2 Aqueous Polishing Process and Chemistry

11.2.1 Conduct of Review

This section of the FSER contains the staff's review of the AP process safety described by the applicant in Section 11.3 of the revised CAR (DCS, 2002e), with supporting process safety information from Chapters 5, 8, and 11 of the revised 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 objective of this review is to determine whether the chemical process safety PSSCs and their design bases provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. 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 of this FSER), the review of fire safety aspects (see Chapter 7 of this FSER), and the review of plant systems (see Chapter 11 of this FSER).

The staff evaluated the AP process and chemistry information in the revised CAR against the following regulations:

- 10 CFR 70.23(a) 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.
- 10 CFR 70.64 requires that BDC and defense-in-depth practices be incorporated into the design of new facilities or new processes at existing facilities. With respect to chemical

protection, 10 CFR 70.64(a)(5) requires that the MFFF design provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material. Related to chemical protection, 10 CFR 70.64(a)(3) requires that the facility design provide for adequate protection against fires and explosions, such as those that could be initiated by or involve chemicals at the proposed facility.

The review of the revised CAR 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 as guidance in performing the review (NRC, 2000).

As stated in the memorandum of understanding (MOU) between the NRC 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. These chemical safety issues are important because they 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 MOU provisions applicable to the proposed MOX facility are now codified in 10 CFR 70.64(a)(5).

The NRC staff reviewed the following areas of the revised CAR applicable to process safety at the construction approval stage and consistent with the level of design (NRC, 2000, p. 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 revised CAR incorporates the BDC of 10 CFR 70.64(a) into the design and operations of the proposed facility (see revised CAR, p. 5.5-53), and applicable sections of the revised CAR are intended to demonstrate compliance with these BDCs. 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. A summary of the major components and functions is discussed in Section 11.2.1.2 of this FSER.

The AP process is designed to receive weapons-grade plutonium from the proposed pit disassembly and conversion facility (PDCF) and alternate feedstock (AFS) at SRS and to remove the impurities from the feed plutonium from the PDCF and AFS for use in the MOX process (MP). There are four major steps in AP:

(1) The first step is the dissolution of plutonium dioxide powder by electrically generated silver (II) ions. The dissolution step involves the use of silver as a catalyst in a nitric acid medium. This electrolytically assisted route is independent of the powder characteristics. Dissolution is complete, with the rate determined by the generation of the silver (II) ions, at relatively mild temperatures (20–40 °C (68–104 °F); nominal temperature 30 °C (86 °F)). Dechlorination is required before dissolution for those powders containing chlorides (i.e., for AFS).

(2) The second step involves plutonium purification by solvent extraction. Purification extracts and recovers plutonium, regenerates the solvent, and recycles nitric acid. Solvent extraction removes impurities such as gallium, uranium, and americium (CAR Section 11.3). The proposed facility would use a modified plutonium uranium reduction extraction (PUREX) process (e.g., Bennedict, 1981).

(3) Third, the process includes conversion into plutonium dioxide by continuous oxalate calcination. Precipitation and calcination of the plutonium oxalate is a standard process used to prepare plutonium dioxide fuels.

(4) Finally, recovery and recycle efforts are completed. Process side streams are treated to recover and recycle chemical reagents and reduce waste generation, as appropriate.

The proposed design of the AP process is similar to the design currently employed at La Hague's plutonium finishing facilities. Departures from the La Hague design result from U.S. regulatory requirements, lessons learned at La Hague, or manufacturing and throughput requirements specific to the facility.

11.2.1.2 Major Components and Functions

The AP process can be segmented into the following four operational areas (unit symbols are provided in parentheses):

(1) plutonium purification process—includes the decanning unit (KDA), dissolution unit (KDB), dechlorination and dissolution unit (KDD), purification cycle (KPA), oxalic precipitation and oxidation unit (KCA), homogenization unit (KCB), milling unit (KDM), canning unit (KCC), and recanning unit (KDR), but no longer includes a uranium oxide dissolution unit

(2) recovery processes—includes the solvent recovery cycle (KPB), oxalic mother liquor recovery unit (KCD), and acid recovery unit (KPC), but no longer includes a silver recovery unit.

(3) waste storage—includes the liquid waste reception unit (KWD) and waste organic solvent unit (KWS)

(4) offgas treatment—includes the offgas treatment unit (KWG)

11.2.1.2.1 Decanning Unit

The decanning unit consists of a series of workstations and gloveboxes distributed between the MP and AP areas. All cans entering the facility via this unit are initially packaged in 3013 standard containers and meet the 3013 standard. For this reason, the staff notes that such powders have been stabilized and are not pyrophoric and do not contain significant volatile species.

The three main functions of the decanning unit include the following:

(1) density measurement (PDCF powders only)

(2) opening of outer, inner, and convenience cans

(3) transfer of powder to a dissolution dosing hopper (PDCF powder) or to a reusable can for the milling unit (AFS powder)

Density is determined from an x-ray level measurement on the entire, sealed 3013 container. Cans containing PDCF powders with a density less than 7 g/cc are sent to the dissolver for processing. Any PDCF powders with densities near or greater than 7 g/cc require ball milling and a subsequent, confirmatory density measurement to meet the less-than-7-g/cc limit. All AFS powders are ball milled. In addition, AFS powders are analyzed as follows:

- If chlorinated species are detected, the reusable can is emptied into the dosing hopper of one of the electrolyzers in the dechlorination and dissolution unit.
- If the powder does not contain chlorinated species, the reusable can is fed into the dosing hopper of the dissolution unit's electrolyzer.
- If the powder contains chemical species not compatible with the AP process, the powder is transferred to the recanning unit for repackaging.

The plutonium feed design basis is discussed in Section 11.2.1.4 of this FSER.

11.2.1.2.2 Milling Unit

The milling unit consists of a series of gloveboxes. The functions of the milling unit are as follows:

- Mill AFS powders to homogenize the plutonium dioxide and decrease the particle size to a level compatible with the dissolution process.
- Perform density measurements on the milled powders.
- Sample the powder for chemical analysis.
- Store powders while awaiting analytical results.

As described in Section 11.2.1.2.1, the AFS powders are analyzed in the laboratory. Depending on the results of those analyses, the powder is transferred to different processes. If the chloride concentration is found to exceed 500 micrograms/gram of plutonium (500 ppm), the powder is directed to the feeding hopper for one of the two dechlorination electrolyzers (dechlorination and dissolution unit). If the chloride level exceeds the design basis values discussed in Section 11.2.1.4, the reusable can is sent to the recanning unit for repackaging in a 3013 container.

11.2.1.2.3 Recanning Unit

The recanning unit consists of two gloveboxes and two workstations designed to repackage powders that are not compatible with the AP process into 3013 containers. The powder is analyzed before transfer out of any unit in the facility. The operations include welding, tightness, and contamination checks.

11.2.1.2.4 Dissolution Unit

The function of the dissolution unit is to dissolve plutonium dioxide powders containing less than 500 ppm chlorides. The plutonium dioxide is electrolytically dissolved in the dissolution unit as a precursor for separating impurities (specifically americium, gallium, and uranium) in the purification cycle. 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 kinetics are improved by augmenting the reaction with a strong oxidizing agent (in this case, by electrolytic dissolution with silver ions (Ag[II])). Silver ions (Ag[II]) are electrolytically produced in a cylindrical compartment. The electrolytic dissolution takes place in a 6 N nitric acid solution at nominally 30 °C (86 °F). The general dissolution process may be described as follows:

<u>Electrolytic production of Ag^{2+} (at the anode)</u>:

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

<u>Dissolution of PuO_2 powder</u>:

$$PuO_2 \text{ (solid)} + Ag^{2+} = PuO_2^{+} \text{ (solid)} + Ag^{+} \quad (11.2\text{-}2)$$

$$PuO_2^{+} \text{ (solid)} + HNO_3 = PuO_2^{+} \text{ (solution)} \quad (11.2\text{-}3)$$

$$PuO_2^{+} \text{ (solution)} + Ag^{2+} = PuO_2^{2+} \text{ (solution)} + Ag^{+} \quad (11.2\text{-}4)$$

This gives the following general reaction:

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

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 (and near-anode) reactions might occur, such as the following:

$$2\,H_2O = O_2 \text{ (gas)} + 4H^{+} + 4e^{-} \text{ (water electrolysis/oxidation)} \quad (11.2\text{-}6)$$

$$2\,Ag^{2+} + H_2O = 2\,Ag^{+} + 2\,H^{+} + (\tfrac{1}{2})\,O_2 \text{ (gas)} \quad (11.2\text{-}7)$$

(water oxidation by silver)

Water oxidation by silver (II) is promoted at temperatures of 40 °C (104 °F) and above (Bourges, 1985). The production of oxygen may have safety concerns. For example, the presence of oxygen can lead to explosions with hydrogen.

The applicant stated that the following reduction reaction takes place at the cathode:

$$NO_3^- + 3H^+ + 2e^- = HNO_2 + H_2O \qquad (11.2\text{-}8)$$

The literature also identifies the following cathode reactions (Bray, 1987, 1992; Bourges, 1985):

$$2\,H^+ + NO_3^- + e^- = NO_2\,(\text{gas}) + H_2O \qquad (11.2\text{-}9)$$

$$4\,H^+ + NO_3^- + 3e^- = NO\,(\text{gas}) + 2\,H_2O \qquad (11.2\text{-}10)$$

Hydrogen generation can also occur at the cathode:

$$2\,H^+ + 2\,e^- = H_2\,(\text{gas}) \qquad (11.2\text{-}11)$$

The staff review notes hydrogen generation usually occurs at a low rate at all times. Under off-normal conditions, such as overvoltage or reduced acid concentrations, hydrogen generation has the potential to increase substantially and become the dominant cathode reaction.

Dissolution occurs when a current is applied. The joule heating effect of the electrical current supplied is reduced by cooling the anolyte and the catholyte. 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. The literature indicates that the silver-assisted plutonium dissolution reaction occurs with 30–70 percent efficiencies (Bray, 1987, 1992; Bourges, 1985). Side reactions almost invariably occur and likely involve the evolution of gases, such as hydrogen, oxygen, and nitrogen oxides. 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 and the companion dechlorination and dissolution unit are designed to treat 22 kg/day (48.51 lb/day) of plutonium dioxide. The operating ranges depend on the quantity of AFS powder processed. During the processing of AFS powder (which may occur over the first 3 years of operation), the dissolution units are anticipated to process between 4 kg/week (8.8 lbs/week) of powder (i.e., one batch from the dechlorination and dissolution unit) up to a maximum of 129 kg/week (284 lbs/week) of powder. This correlates to six dissolutions per week for both lines of the dechlorination and dissolution unit and six batches of the single line in the dissolution unit (13.5 kg/batch (29.8 lb/batch)). During the processing of PDCF powders, the minimum processed is expected to be 13.54 kg/week (29.8 lbs/week) of powder (i.e., one batch through the single electrolyzer of the dissolution unit). The maximum processed is estimated as 243 kg/week (536 lbs/week) of powder, corresponding to six dissolutions per week for all three electrolyzers. The nominal flow rate to the purification cycle is approximately 14.4 L/h (3.8 gal/h).

Hydrogen peroxide is added to the receiving tank used for interim storage in order to adjust the oxidation state of the plutonium from (VI) to (IV). A plutonium (IV) oxidation state allows for better extraction and separations processing. The peroxide also reduces any excess silver (II) to silver (I). The uranium impurity exists as the ^{235}U isotope (from radioactive decay of ^{239}Pu and nonseparable portions of the original pit—essentially more than 93 percent uranium enrichment or assay). Consequently, an isotopic dilution to around 30 percent assay is made by feeding the appropriate quantity of depleted uranium nitrate solution (0.25 percent ^{235}U) to the dilution and sampling tank. Other adjustments (e.g., acidity) may also be made to the solution in the dilution and sampling tank to optimize subsequent purification of the plutonium.

11.2.1.2.5 Dechlorination and Dissolution Unit

The dechlorination and dissolution unit includes two electrolyzers, each the same size as the single electrolyzer in the dissolution unit. However, as noted previously, batch sizes are different depending on the feed material.

The functions of the dechlorination and dissolution unit are to remove chloride ions from the plutonium dioxide powder and then dissolve the material. The unit processes powders with chloride levels exceeding 500 ppm. The unit can also be used to process nonchlorinated feed materials (e.g., the PDCF feed).

Each electrolyzer line includes a scrubbing column for the removal of chlorine. The electrolyzers are operated in two modes. The first mode is dechlorination—electricity is applied and the chlorine gas is evolved at the anode as follows:

$$2\ Cl^- = Cl_2\ (g) + 2\ e^- \qquad (11.2\text{-}12)$$

The applicant indicated that the process removes greater than 99 percent of the initial chloride in the powder, based on operation with 6 N nitric acid and a temperature of 60 °C (140 °F).

In the second mode of operation (i.e., after chloride removal), the electrolyzer is operated in a manner completely analogous to the dissolution unit electrolyzer. Silver ions are fed into the electrolyzer, and the powder is dissolved.

11.2.1.2.6 Purification Cycle

The purification cycle uses a modification of the standard PUREX process (Bennedict, 1981). Plutonium nitrate from the dissolution unit is received, and plutonium is solvent 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 includes plutonium reception, recycle, and transfer to the oxalic precipitation and oxidation unit. The purification cycle also sends the solvent/diluent stream to the solvent recovery cycle and the raffinate stream to the acid recovery unit.

The main goal of the purification cycle is to separate plutonium from impurities contained in the solution coming from the dissolution unit. In the revised CAR, the applicant identified the main functions of the purification cycle as follows:

- Receive plutonium nitrate from the dissolution unit and the dechlorination and dissolution unit.
- Receive recycled plutonium nitrate from the oxalic mother liquor recovery unit.
- Receive solutions with high plutonium content from the laboratories.
- Perform plutonium extraction and impurities scrubbing.
- Perform plutonium stripping and uranium scrubbing.
- Perform further plutonium purification by additional plutonium stripping and diluent washing.
- Adjust plutonium to the tetravalent state.
- Perform plutonium stripping in a plutonium barrier.
- Perform scrub bed uranium stripping and diluent washing.
- Control purified plutonium and transfer to the oxalic precipitation and oxidation unit or recycle to the beginning of the purification cycle.
- Control and dilute scrubbed uranium and prepare uranium for transfer to the liquid waste reception unit.
- Wash, control, and transfer raffinates to the acid recovery unit.
- Wash, control, and transfer solvent/diluent to the solvent recovery cycle.
- Destroy residual hydroxylamine nitrate (HAN)/hydrazine and hydrazoic acid in the aqueous phase transferred to the oxalic precipitation and oxidation 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. Plutonium (IV) in the aqueous solution (4.5 N HNO_3) is extracted by the solvent (30 percent tributyl phosphate (TBP) in a branched dodecane—the latter is sometimes referred to as hydrogenated propylene tetramer (HPT)) in a pulsed extraction column. The impurities remain primarily in the aqueous phase. The solvent stream is scrubbed by 1.5 N 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.

Plutonium (IV) is reduced to plutonium (III) by HAN ($[NH_3OH^+][NO_3^-]$), and plutonium (III) is stripped in a pulsed stripping column (Reactions 11.2-13 and 11.2-14). Hydrazine nitrate is introduced to prevent parasitic reoxidation of plutonium (III) back to plutonium (IV) (Reactions

11.2-15 and 11.2-16). The stripped plutonium is washed with diluent in a pulsed diluent washing column before the final valence adjustment. Unstripped plutonium is extracted in the plutonium barrier mixer-settler bank. Hydrazine nitrate and HAN are introduced in the last stage of the plutonium barrier. The solvent from the plutonium barrier flows to the uranium-stripping mixer-settler bank. These reactions are written as follows:

Plutonium reduction by HAN ($NH_3OH[NO_3]$):
$2[NH_3OH]^+ + 4Pu^{+4} = 4Pu^{+3} + N_2O(g) + H_2O + 6H^+$ (11.2-13)
$2[NH_3OH]^+ + 2Pu^{+4} = 2Pu^{+3} + N_2(g) + 2H_2O + 4H^+$ (11.2-14)

Plutonium reduction by hydrazine:
$4Pu^{4+} + N_2H_5^+ + H_2O = 4\ Pu^{3+} + N_2O + 5\ H^+$ (11.2-15)

Parasitic reoxidation of Pu(III) to Pu(IV):
$2Pu^{3+} + 2HNO_2 + 3H^+ + NO3^- = 2Pu^{4+} + 3HNO_2 + H_2$ (11.2-16)

Uranium is stripped (recovered from the organic phase) in a slightly acidic 0.02 N nitric acid 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. Isotopic dilution with depleted uranium nitrate solution is performed as necessary. 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 plutonium (III) to plutonium (IV) is achieved by oxidizing the plutonium (III) solution with nitrous fumes (essentially a nitrogen dioxide/nitrogen tetraoxide 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 40 g/L (0.34 lb/gal) at the outlet of the purification cycle.

The purification cycle operates continuously. The feeding solutions from the dissolution unit are received in batches. Thus, the nominal flow rate to purification is approximately 15.1 L/h (4 gal/h). This cycle is designed to process 14.5 kg/day (32 lb/day) of plutonium. The operating range of the purification cycle is 11–19 kg/h (24.3–42 lb/h) of plutonium.

11.2.1.2.7 Solvent Recovery Cycle

The solvent recovery cycle operates continuously in conjunction with the purification cycle. Standard PUREX methods are used to wash the solvent and remove the degradation products.

In the revised 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 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. Effluent in this section refers to effluent from individual process units to other process units; the facility discharges no radioactive liquid effluent directly into the environment.

Washing removes undesirable byproducts, such as hydrazoic acid and TBP degradation products, from the solvent to prevent their accumulation and associated deleterious impact upon process and safety performance. The solvent is washed by contact with an aqueous solution of sodium carbonate and sodium hydroxide in mixer-settler banks. Washing removes hydrazoic acid (as sodium azide) and TBP degradation products (mainly monobutyl phosphate and dibutyl phosphate) from the solvent to the aqueous stream. 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 1 when recycling is in operation.

The unit is designed to treat solvents at a flow rate of 17.4 L/h (4.6 gal/h), which corresponds to 14.2 kg/day (31.7 lb/day) of plutonium.

11.2.1.2.8 Oxalic Precipitation and Oxidation Unit

In the revised CAR, the applicant identified the functions of the oxalic precipitation and oxidation unit as follows:

- Receive purified plutonium nitrate concentrated to approximately 40 g/L (0.34 lb/gal) from the purification cycle and prepare uniform batches.
- Precipitate out the plutonium nitrate as oxalate.
- Produce plutonium dioxide 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 plutonium dioxide to the homogenization unit and transfer the mother liquors and the filter washing solutions to the oxalic mother liquor recovery unit. Solutions are transferred by air lifts and flow control valves as described in Section 11.3.2.8.2 of the revised CAR.

- Ensure reducing agents, hydrazoic acid, and plutonium (VI) do not propagate into downstream processing units (e.g., the oxalic mother liquor recovery unit).

The following depicts the precipitation reaction:

$$Pu(NO_3)_4 + 2\ H_2C_2O_4 = Pu(C_2O_4)_2\ (s) + 4\ HNO_3 \qquad (11.2\text{-}17)$$

The conversion line is rated for the processing of 1.1 kg/h (2.3 lb/h) (25.7 kg/day (56.6 lb/day)) of plutonium. The operating range of the oxalic precipitation and oxidation unit is 0–1.25 kg/h (2.75 lb/h) 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 0.6 m^3 (21.2 ft^3 or about 158.5 gal). Solutions are transferred by a pump to two dosing wheels, which supply one precipitator each. The solutions flow by gravity 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 plutonium dioxide in an oxidizing atmosphere of oxygen. The following shows the overall reaction:

$$Pu(C_2O_4)_2 + O_2 = PuO_2 + 4\ CO_2 \qquad (11.2\text{-}18)$$

The staff notes that this is plutonium (IV) oxalate, which generally requires a higher temperature (400–500 °C) for conversion to the oxide than either plutonium (III) or plutonium (VI) oxalates (around 200 °C). Potential concerns and controls for plutonium (VI) oxalate are discussed further in Section 8.1.2.5.1.6 of this FSER. Potential concerns and controls with plutonium (III) oxalate are discussed in Section 11.3 under plutonium pyrophoricity.

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 3.3 N with recovered 13.6 N 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 (e.g., carbon dioxide and steam, nitric oxides, and trace organics), the excess of oxygen, and the air from upstream and downstream of the process are removed by a negative-pressure circuit. This system comprises a filter, a condenser, a demister, an electric heater, two high-efficiency particulate air (HEPA) filters, and two fans.

11.2.1.2.9 Homogenization Area

The plutonium dioxide 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. The plutonium material balance is determined by weighing the filled cans (canning unit) and by determining the plutonium content of the hopper by powder sampling. Sampling ensures that all the finished product specifications are met in each batch of plutonium dioxide in each hopper and checks the isotopic composition of the plutonium dioxide for the finished product of each batch in each hopper.

In the revised CAR, the applicant identified the functions of the homogenization unit as follows:

- Receive and homogenize the plutonium dioxide produced in the oxalic precipitation and oxidation unit.

- Fill cans with plutonium dioxide 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.

11.2.1.2.10 Canning Unit

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

- plutonium dioxide inlet from the homogenization unit—1.2 kg/h (2.6 lb/h)
- plutonium dioxide outlet—approximately 10 full reusable cans per day

11.2.1.2.11 Oxalic Mother Liquor Recovery Unit

In the revised 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 remove plutonium from the distillates.

- Check and transfer the distillates to the acid recovery unit.

- Monitor and recycle, batchwise, the concentrates to the top of the purification cycle.

The nominal capacity corresponds to the processing of the materials generated by the precipitation of 24 kg (HM)/day (52.9 lb/day) of plutonium. This translates into a liquor flow rate of approximately 250 L/h (66 gal/h). 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 3 days capacity. This allows for the independent operation of the two units. The mother liquor solution flows by gravity into the buffer tanks (two tanks, about 1 m^3 (264 gal) each). After sampling for plutonium concentration, an airlift transfers the solution into a feed tank (also of 1 m^3 (264 gal) 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 nitric oxide. The following equations depict these reactions:

$$Pu(C_2O_4)_2 + 4\ HNO_3 = Pu(NO_3)_4 + 2\ H_2C_2O_4 \text{ (Mn(II) as catalyst)} \qquad (11.2\text{-}17)$$

$$H_2C_2O_4 + 2\ HNO_3 = 2\ CO_2 + 2\ NO_2 + 2\ H_2O \text{ (Mn(II) as catalyst)} \qquad (11.2\text{-}18)$$

The evaporator exposes the plutonium nitrate to prolonged boiling (100-135 °C (212-275 °F)) 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:

$$3\ Pu^{+3} + HNO_3 + 3H^+ = 3\ Pu^{+4} + NO + 2\ H_2O \qquad (11.2\text{-}19)$$

$$3\ Pu^{+4} + 2\ H_2O = 2\ Pu^{+3} + PuO_2^{+2} + 4\ H^+ \quad \text{(Mn(II) as catalyst)} \qquad (11.2\text{-}20)$$

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 for the plutonium concentration by an online neutron counter. In the revised CAR, the applicant stated 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 recycling and retreatment.

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

11.2.1.2.12 Acid Recovery Unit

In the revised CAR, the applicant identified the following functions for the acid recovery unit:

- Receive extraction raffinates from the purification cycle, oxalic mother liquor distillates from the oxalic mother liquor recovery unit, and effluents from laboratories in batches and continuously receive active liquid effluents from the offgas treatment unit equipment ventilation.
- Concentrate the radioactivity contained in the effluents and send it to the liquid waste reception unit.
- Recover concentrated acid for recycling in the process.
- Recover distillates from the rectification column for use in the offgas treatment unit and the purification cycle, with excess liquid to the liquid waste reception unit.

The acid recovery unit uses evaporation as the principal treatment method. The feed tank receives the following materials:

- raffinates from the purification cycle in 1500 L (396 gal) batches
- oxalic mother liquor distillates (oxalic mother liquor recovery unit evaporator 3000) in 2500 L (660 gal) batches
- recombined acid from the offgas treatment unit (continuously)
- effluents from laboratories in batches

The solution is transferred by double-stage airlifts from the feed tank 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 500 L (132 gal) tank discontinuously, several times a day. The concentrates contain the americium and gallium impurities and are sent to the liquid waste reception 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 the 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 drawoff 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 recycling. Any excess recycle water is analyzed and temporarily stored before transfer by pump to the liquid waste reception unit.

11.2.1.2.13 Silver Recovery Unit

The applicant decided to eliminate the silver recovery unit for economic reasons. The silver nitrate used in the dissolution unit is part of the high alpha waste stream that will be sent to the acid recovery unit.

11.2.1.2.14 Offgas Treatment Unit

The offgas treatment unit ventilation system is dedicated to maintaining a system negative pressure for AP process confinement and for removal vapors and gases from processing equipment. In the revised CAR, the applicant identified the following functions of this unit:

- Remove plutonium from offgases collected from the dissolution unit, the dechlorination and dissolution unit (during the dissolution step), the oxalic precipitation and oxidation unit, the oxalic mother liquors recovery unit, the acid recovery unit, the liquid waste reception unit, and the oxidation and degassing columns (purification cycle).

- Recombine the nitrous fumes in a specific nitric oxide scrubbing column.

- Clean, by water scrubbing, the offgases collected from all AP units.

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

The offgases containing nitric oxide (from dissolution/oxidation and degassing columns) are gathered downstream of a cap impactor to remove droplets. The collected effluent stream is recycled, by gravity, to the oxalic mother liquor recovery. Offgases are then scrubbed with recycled effluents and with recovered distillates from the acid recovery unit. The offgases pass through a demister, using an air ejector to provide the motive force. The extraction rate is regulated based on the pressure in the scrubbing column.

Normal ventilation gases (i.e., process vents) are combined with the treated nitric oxide 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 (2×2), and an exhauster before release 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 (2×2), and an exhauster before release through the stack.

The offgas treatment unit operates continuously. The nitric oxide scrubbing column is designed to treat approximately 62 N m^3/h (36 cubic feet per minute (cfm)). The main ventilation line (offgas scrubbing and filters) is designed to process approximately 600 N m^3/h (350 cfm). The designed capacity of the column pulsation air extraction is 150 N m^3/h (88 cfm).

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

11.2.1.2.15 Liquid Waste Reception Unit

The liquid waste reception unit receives liquid waste from the AP process for temporary storage before sending it to SRS for treatment and processing (see Sections 11.3.2.14 and 10.1.4 of the revised CAR). Waste stream descriptions and quantities are summarized in Table 11.2-1. The functions of this unit are to treat the following liquid waste streams:

- The low-level liquid waste stream, which comprises of (1) the room HVAC condensate, rinse water from laboratories, and washing water from sanitaries which are potentially noncontaminated and are collected as low-low-level liquid waste, (2) the distillate stream from the acid recovery unit which is contaminated and slightly acidic, (3) miscellaneous floor washes from C2/C3 rooms and overflows or drip tray material from some of the reagent tanks in the AP building, and (4) the chloride stream from the scrubbers used during the dechlorination step for AFS feeds (i.e., from the dechlorination and dissolution unit).

  [Text removed under 10 CFR 2.390]

- The high alpha waste stream is a combination of three waste streams—americium, alkaline waste, and excess acid. The americium stream collects americium and gallium nitrates and all of the silver used in the dissolution unit, along with traces of plutonium. The alkaline waste stream from the solvent recovery area contains dilute caustic soda (NaOH), sodium carbonate, sodium azide, and traces of uranium and plutonium. The excess acid stream from the acid recovery unit contains high alpha activity excess acid. The high alpha storage tank along with the high alpha buffer storage tank are a holding point for high alpha wastes and provide 90 days of storage.

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- The stripped uranium (less than 1 percent ^{235}U) waste stream receives the contents of the uranium dilution tanks in the purification cycle.

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11.2.1.2.16 Waste Organic Solvent Unit

The function of the waste organic solvent unit is to handle the organic solvent generated by the process and transfer it to SRS for handling and disposal.

The unit consists of an intermediate solvent tank, a final solvent tank, and a carboy filling station. It is designed to collect waste solvent for sampling in order to assure compliance with the SRS waste acceptance criteria (WAC).

The intermediate solvent tank is located in a closed process cell and has mixing and automatic sampling capabilities. Sampling is conducted to determine compliance with the SRS WAC. If the waste solvent meets the WAC, it is transferred to the final waste solvent tank.

The final waste solvent tank receives solvent from the intermediate tank and from the solvent recovery cycle unit solvent tank. This final tank is located in an open process cell and has mixing and manual sampling capabilities. Waste solvent is transferred from this tank to a

Table 11.2-1 Waste Stream Descriptions and Quantities in the Waste Reception Unit

Waste Stream Designation	Annual Volume, Liters (gal)	Main Chemical or Isotope	Disposition, Liters (gal)
Liquid americium stream (concentrated stream from acid recovery)	11,400 (3,000) (PDCF) 16,700 (4,400) (AFS)	^{241}Am < 24.5 kg/y (54 lb/y) (3.1×10^{15} Bq (84,000 Ci)) Pu <150 g/y (0.33 lb/y) Hydrogen ions—9.4 N Nitrate salts—2200 kg/y (4850 lb/y) from silver nitrate Silver < 300 kg/y (661 lb/y) Trace quantities of thallium, lead, and mercury	High alpha waste to WSB 39,000 (10,300) (PDCF) 31,900 (8,421) (AFS)
Excess acid Stream	5,000 (1,321) (AFS) 15,500 (4,100) (PDCF)	Am < 90 mg/y (2×10^{-4} lb/y) (rectification step after two evaporation steps) Hydrogen ions—13.6 N	
Alkaline stream	12,100 (3,200) (PDCF) 10,200 (2,700) (AFS)	Pu < 16 g/y (0.035 lb/y) U < 13 g/y (0.029 lb/y) Na < 110 kg/y (243 lb/y)	
Stripped uranium stream	167,000 (44,000) (PDCF) 151,000 (40,000) (AFS)	Pu < 0.1 mg/L U < 3100 kg/y (6834 lb/y)(1% assay) Hydrogen ions—0.14 N	Stripped uranium to WSB 167,000 (44,000) (PDCF) 151,000 (40,000) (AFS)
Excess low-level radioactive solvent wastes	10,600 (2,800) (PDCF) 9,800 (2,600) (AFS)	Solvent—30% TBP in dodecane Pu < 17.2 mg/y (3.8×10^{-5} lb/y)	LLW solvent to SRS solvent recovery 10,600 (2,800) (PDCF) 9,800 (2,600) (AFS)
Distillate waste	386,000 (102,000) (PDCF) 265,000 (70,000) (AFS)	^{241}Am-241 < 0.85 mg/y (1.9×10^{-6} lb/y) Activity—2.39×10^{8} Bq/y Hydrogen ions—0.02 N	Liquid LLW 1,080,000 (285,000) (PDCF) 1,030,000 (273,000) (AFS)
Chloride removal waste	75,700 (20,000) (AFS)	Only when processing AFS materials Chloride < 5 g/L (0.04 lb/gal)	
Rinsing water	598,000 (158,000) (PDCF) 598,000 (158,000) (AFS)	Alpha activity < 4 Bq/L Hydrogen ions—0–0.6 N	
Internal HVAC condensate	94,600 (25,000)	Trace contamination	

carboy. The slightly contaminated solvent is anticipated to be a low-level waste (LLW). This waste is stored in a 300-gallon carboy or other suitable vessel and transferred by truck to SRS for disposition.

11.2.1.2.17 Uranium Dissolution Unit

The applicant decided to purchase depleted uranium nitrate solution as a reagent from an outside supplier. Consequently, the uranium dissolving unit has been eliminated from the proposed facility (DCS, 2002e).

11.2.1.2.18 Sampling System

The sampling system is used for radioactive and chemical solutions. Section 11.3.2.16 of the revised CAR discusses the following three liquid sampling system approaches that the applicant intends to use at the facility:

(1) 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.

(2) In suction sampling, a vial is filled by suction through a needle by the vacuum in the vial. Aggressive reagents can be sampled manually but with vacuum vial filling. Particles are not expected in the sampling system because all AP process solutions are expected to be clear. A moving cask is used for suction filling of active liquids.

(3) 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 stated that all sampling systems will be qualified using engineering studies and/or evaluations.

11.2.1.3 Staff Review of the AP Process System

11.2.1.3.1 Chloride Concentration of AFS Powder (KDM)

The staff evaluated the risk to the site worker and the individual outside the controlled area (IOC) from chlorine emissions resulting from AP processes into the environment. Alternate plutonium dioxide feedstock that contains greater than 500 ppm chloride salts would be processed in the dechlorination electrolyzers. The maximum concentration of chloride salts in alternate feedstock is expected to be a mass fraction of 20–33 percent chloride. If such a high chloride-containing stream is directed to the normal (nondechlorination) dissolution electrolyzer, which does not have a chlorine scrubber, by mistake, up to 3–5 kg (6.6–11 lbs) of chlorine gas could be released. This would result in an intermediate-level consequence to the IOC if the release were to occur in less than 1 hour. The staff identified this as Open Item AP-07 in the revised draft safety evaluation report (DSER) (NRC, 2003c).

The staff has analyzed this event and concludes that the electrical current necessary to evolve this rate of material would be significantly larger than the steady-state load of the electrolyzer, and that the electrical current would have to exist for a relatively long time (15–60 minutes or more) and would likely exceed standard protection devices, such as circuit breakers, and/or the capacity of the electrolyzer itself. The controls would likely terminate the current before significant quantities of chlorine could be evolved. Thus, the staff concludes that this is an unlikely or highly unlikely event, and that no additional controls are necessary to meet the performance requirements in 10 CFR 70.61. "Performance Requirements." This closes AP-07 from the revised DSER (NRC, 2003c).

11.2.1.3.2 Electrolyzers (KDB and KDD)

The applicant provided information (DCS, 2001) that discussed a loss of confinement scenario for the electrolyzer, based on an overtemperature situation caused by a control system failure, electric isolation failure, or a loss of cooling

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The applicant concluded that the event must be either prevented or mitigated and selected a prevention strategy to reduce the risk to the facility worker and the environment, based on shutdown of the electrolyzer and natural cooling. The applicant identified the safety design basis as the detection of the high temperature (identified as greater than 70 °C (158 °F)) 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 a termination of the electrical current. The PSSCs identified by the applicant are the temperature and shutdown controls, as well as the process safety instrumentation and control (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; these are not identified as PSSCs. The applicant also stated that the scavenging and emergency air systems would be used to preclude the possibility of explosions, based on the rate of hydrogen generated by radiolysis. Consequently, the applicant indicated that the voltage to the electrolyzer would be limited.

The safety strategy for the site worker and the IOC relies upon mitigation features. The PSSC is the C3 confinement system, which has the safety function of filtering radioactive materials from the C3 air before release into the atmosphere.

In subsequent discussions (DCS, 2002d; NRC, 2002c), the applicant indicated that there will be multiple, redundant temperature sensors located at the highest temperature location(s). These would provide temperature signals to the process safety I&C system (a PSSC), which would terminate electrical power. The applicant has also stated the temperature design basis of 70 °C (125 °F) incorporates the effects of potential reaction exotherms. The power is actually terminated before the temperature reaches 70 °C (125 °F).

The NRC staff conducted a literature review on the electrical dissolution of plutonium dioxide (Bray, 1987, 1992; Bourges, 1985). Key points from this review are as follows:

- Plutonium dioxide from different sources and calcination conditions (e.g., high-fired) can be effectively and rapidly dissolved.
- Multiple reactions are involved.
- Current efficiencies are in the 30–70 percent range.
- Nitric oxide is formed at the cathode; ammonia/ammonium ions can also be produced.
- Hydrogen is produced over a wide range of acidities and cathodic materials; at catholyte concentrations below about 2 N nitric acid, measured hydrogen gas concentrations exceeded 1 percent in the evolved gases. Potential reactions between evolved hydrogen and nitric oxide were not discussed.
- Hydrogen is a concern because of potential flammability in the gas space and hydrogen embrittlement in certain metals used in construction (e.g., titanium).
- Polarization curves were not available.

Several safety or operational limits are mentioned in the literature, which would require shutting off the power if exceeded. These limits include catholyte density (e.g., an indirect measure of acid concentration), catholyte flow, offgas hydrogen concentration, offgas flow, cell temperature, anolyte cooling water flow, catholyte cooling water flow, cell applied voltage, and cell current. Conductivity and radioactivity monitoring for the cooling water were mentioned as a possible alarm condition. The staff also notes that cooling water inflow into the catholyte (e.g., from a leak) would change acid concentrations and potentially increase hydrogen generation rates.

In the revised CAR, an overtemperature event with the electrolyzer is identified in the category of a loss of confinement. The safety strategy for the facility worker and the environment utilizes prevention features. The PSSC is the process safety control subsystem. The safety function is to shut down process equipment before exceeding a temperature safety limit (i.e., the 70 °C (125 °F) design basis). The applicant stated that the temperature limit will be established by considering all material limits associated with the glovebox (NRC, 2002c). The applicant will perform final calculations and identify specific temperature setpoints in support of its ISA, based on the codes and standards identified in Section 11.6.7 of the revised CAR. This will assure that, subsequent to the shutdown of process equipment, normal convective cooling is sufficient (NRC, 2002c).

On page 11.6-16 of the revised CAR, setpoint design bases for the process safety control subsystem are identified as ANSI/ISA-67.04.01-2000. From clarifications provided during the August in-office review (NRC, 2002c), the applicant indicated that the setpoint analysis will consider electrolysis, potential exotherms from reactions, and natural cooling effects. The staff concludes that this approach provides assurance that the design basis temperature of 70 °C (125 °F) will not be exceeded, provides margin (i.e., vis-a-vis the boiling point of the solution, around 110 °C (230 °F)), and provides assurance that the control strategy will adequately prevent the overtemperature event. The staff has determined this to be acceptable for the CAR stage. Thus, Open Item AP-01 from the original DSER (NRC, 2002b) is now considered closed.

11.2.1.3.3 Hydrogen Production (KDB, KDD, KPA, KCA, KWG, and KWD)

The staff review noted that electrolytically generated hydrogen from overvoltage conditions and off-normal concentrations could produce hydrogen concentrations exceeding the lower flammability limit (LFL) if the scavenging airflow is based only upon radiolysis. In addition, overvoltage conditions could produce other undesirable effects, such as different reaction products and gases, flow oscillations, sparking, and greater heating.

In the revised CAR, the applicant identified the design basis for radiolytic hydrogen production as 25 percent of the LFL. The LFL is identified as 4 percent of hydrogen in air under normal conditions. A prevention strategy has been selected (see revised CAR p. 5.5-33), utilizing the PSSCs of the instrument air system (supplying scavenging air) and the offgas system (providing an exhaust path). The staff review notes that hydrogen is principally generated by radiolysis (on the anode side of the electrolyzer) and electrolysis (on the cathode side of the electrolyzer). The anode and cathode sides of the electrolyzer may be separated by membranes (i.e., the liquid phase) but will likely share a common header for venting to the offgas system.

Page 8-17 of the revised CAR discusses hydrogen produced by electrolysis. The design basis is stated as 25 percent of the LFL. A prevention strategy has been selected (see Section 5.5.2.4.6.13 of the revised CAR, p. 5.5-40), utilizing the process safety control subsystem as the PSSC. The safety function is to limit the generation of hydrogen from electrolysis by ensuring that the acid normality is sufficiently high and produces an offgas that does not exceed the design basis (25 percent of the LFL). Acid normality measurements would be instrumented, and normality would be maintained by the PSSC of chemical safety controls (NRC, 2003a). The applicant indicated that voltage control might also be used.

The applicant identified approaches for calculating LFLs for flammable gas mixtures and conditions removed from normal temperatures and pressures (NRC, 2003b; DCS, 2003f). The methodology for mixtures is based on a sum of fractions approach. Graphs were used to show the impact of temperature and pressure—pressure was not thought to be a concern for the MFFF because of the lack of high pressures within the buildings.

The staff notes that the general industrial practice is to use 25 percent of the LFL or less as the design basis for flammable gases in air (NRC, 1999; WSRC, 2000). A 25-percent limit is mentioned in Section 11.9.5.1 of the revised CAR for radiolytically generated hydrogen in and around process-type systems, using scavenging air. During off-normal or accident conditions, scavenging air is provided by the PSSC of the emergency scavenging air subsystem of the instrument air system. This emergency scavenging air is provided to those vessels where radiolytic hydrogen generation could exceed 4-percent hydrogen (the ambient LFL) in 7 days or less if venting and dilution were not maintained; the design basis for the scavenging air would still be 1-percent hydrogen (i.e., 25 percent of the ambient LFL).

As part of its review, the staff considered the following facts:

- The MOX standard review plan (SRP), NUREG-1718, mentions a 25-percent LFL limit for hydrogen in noninerted systems (NRC, 2000).

- The NRC used 25 percent of the LFL for hydrogen in a manner analogous for tank ullages in a radiochemical plant review (NRC, 1999). Consideration for this limit included

National Fire Protection Association (NFPA) code evaluation, radiolysis, chemical reactions, and uncertainties in ventilated process equipment in radiochemical facilities.

- The NRC inspects fuel cycle facilities based on not exceeding 25 percent of the LFL.
- The Department of Energy (DOE) uses 25 percent of the LFL for waste tanks and facilities at SRS and Hanford in a manner analogous to design basis.
- The SRS has hydrogen monitors installed in many ventilated tanks; these are set to alarm at 10 percent of the LFL (WSRC, 2000).

National Fire Protection Association (NFPA) 69, "Standard on Explosion Prevention Systems," issued 1997 (NFPA, 1997) and 801, "Standard for Fire Protection for Facilities Handling Radioactive Materials," issued 1998 (NFPA, 1998), emphasize 25 percent of LFL as an acceptable safety limit. The NFPA allows exceptions if they are justified (e.g., interlocks and well-defined systems and chemistry, multiple continuous monitoring); such exceptions can allow concentrations up to 60 percent of the LFL.

In the revised CAR, the applicant identified the design basis for hydrogen as NFPA 69 (NFPA, 1997). For hydrogen, the applicant identified the controls described below for groups of process equipment.

Group No. 5. Hydrogen Concentration Associated with Radiolysis

For inside equipment that has the potential for hydrogen concentration associated with radiolysis, the applicant proposed a design basis value of 25 percent of the LFL. This limit is in accordance with NFPA 69 (NFPA, 1997).

The safety function of the waste reception unit offgas treatment system is to provide an exhaust path for the removal of diluted hydrogen gas in process vessels. The instrument air system (scavenging air) has the safety function to provide sufficient scavenging air to dilute the hydrogen that is generated during radiolysis.

Group No. 6. Hydrogen Generated by Electrolysis within the Dissolution Process

For inside equipment that has the potential for hydrogen gas concentration associated with electrolysis within the dissolution unit, the applicant proposes a design basis value of 25 percent of the LFL. This limit is in accordance with NFPA 69 (NFPA, 1997).

The safety function of the process safety control system (PSCS) is to limit the generation of hydrogen by ensuring that the normality of nitric acid is sufficiently high to ensure that the offgas is not flammable.

The applicant's refined design basis of NFPA 69 for Groups 5 and 6 (maintain the combustible concentration at or below 25 percent of the LFL) is consistent with the previously cited NRC, DOE, and industry practice for similar applications, addresses combustible vapors present in these groups, and should provide adequate margin. The staff also interprets the design basis of NFPA 69 to apply to normal, off-normal, loss of power, and accident conditions. Consequently, the staff finds the 25 percent of LFL design basis acceptable for the CAR stage.

The control strategy for radiolysis is based on active dilution and active ventilation. This strategy has the ability to maintain concentrations of hydrogen below the design basis of 25 percent of the LFL and is acceptable to the staff for the construction authorization.

The strategy for electrolysis is based on acid normality control. The staff notes that acid normality can be monitored by density or other techniques that may be instrumented, with concentration adjusted by chemical additions. Additional administrative controls may be necessary; however, the applicant already has a PSSC entitled chemical safety controls for chemical makeup that could be used if needed. Specific details would be supplied by the applicant as part of any later license application. The staff conducted a review of the public literature and found curves relating hydrogen production to acid normality. Figure 11.2-1 gives two examples. Hydrogen can be produced over a wide range of acidities and cathodic materials; at catholyte concentrations above approximately 2 N HNO_3, measured hydrogen gas concentrations are below 1 percent (25 percent of the ambient LFL) in the evolved gases and thus would also be below 25 percent of the LFL in the ullage spaces above the electrolyzer. Consequently, the staff concludes that acid normality has the ability to be monitored and controlled in order to reduce combustible gases below 25 percent of the LFL, and this strategy is acceptable for construction authorization.

Therefore, Open Item AP-02 from the revised DSER (NRC, 2003c) has been adequately addressed and is now considered closed for the CAR phase.

The staff has reviewed the standards cited as design bases for combustible/hydrogen gas detectors (see Section 11.6.7 of the revised CAR). The staff notes that the proposed standards are used extensively in the industry in similar situations for combustible and hydrogen gas monitoring, as part of control, alarm, and emergency control systems. The staff finds the standards acceptable for the construction authorization stage.

11.2.1.3.4 Titanium Reactions (KDB and KDD)

The staff evaluation found that the applicant's proposed AP process uses oxidation-reduction chemistry based on the silver (I) to silver (II) couple. Silver (II) is corrosive, and special alloys are necessary for the electrolyzer equipment. The applicant stated that it intends to use titanium for the electrolyzer circuit and associated equipment that could be exposed to silver (II) ions (DCS, 2001). The applicant identified a negligible corrosion rate for titanium in the presence of silver (II) and nitric acid. The applicant intended to destroy silver (II) (i.e., by conversion into silver (I)) before the solutions contact other equipment in the process that is 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 (Bray, 1987, 1992; Bourges, 1985), is needed for adequate corrosion resistance in the presence of aggressive conditions that are likely to exist in this electrolyzer. However, titanium is a reactive metal, and the industry has developed guidelines for the safe use of such alloys, particularly for protection during wet/dry cycling and heating (DOE, 1994; NFPA, 2000; Mahnken, 2000; Poulson, 2000; PSC, 2001; TI, 2004). In addition, each electrolyzer operates with several hundred amps of current and multiple tens of volts, which could serve as an ignition source for the titanium in certain accident sequences. The staff notes that, under certain conditions, titanium fines or thin components exposed to hot sparks can ignite and burn, and incidents have been reported of unanticipated fires in titanium heat exchanger tube bundles, packing, and turbine blades (Mahnken, 2000). However, the staff also recognizes that bulk titanium components can burn only under extreme conditions.

The applicant described its safety approach for titanium events in the electrolyzer in its revised CAR (DCS, 2002e) and in supporting letters (DCS, 2003d, 2003g, 2004a; NRC, 2003d). The electrolyzer is a vertical cylinder with separate anode and cathode compartments. The compartments are concentric with the vertical axis. The cathode compartment is in the center while the anode compartment forms an annulus around it. The two compartments are separated from each other by a sintered silicon nitride (Si_3N_4) barrier (sometimes called a porous frit, or frit). Elastomeric materials are used to insulate and separate the cathode and anode structures, the anode and the ground, and the anode and the titanium shell.

The safety strategy is to prevent the titanium events during normal, abnormal, and shutdown and maintenance of the electrolyzer. During shutdown and maintenance, the applicant proposed to use administrative controls associated with the isolation of power to the electrolyzer when the electrolyzer is drained. For normal and abnormal operations, the applicant proposed a combination of active and passive engineered features to prevent the titanium events.

As noted previously, the anode and anodic compartment circuit connect to the positive terminal of the rectifier (direct current (dc) power) system. At the anode (a platinum electrode), the electricity oxidizes the silver (I) ions to silver (II) in the anolyte solutions, which subsequently react with and dissolve the plutonium dioxide powders. The cathode and cathodic compartment circuit connect to the negative terminal of the rectifier system. At the cathode (a tantalum electrode), reduction reactions occur, primarily forming nitrous acid from nitric acid.

The silicon nitride barrier between the anode and cathode compartments is nonconductive, has a high dielectric strength, and has sufficient porosity to allow ionic current transfer, but insufficient porosity to allow mixing of the anode and cathode solutions. Thus, the silicon nitride prevents the passage of material between the compartments while facilitating ionic electron transfer (the ions transfer the electric current, thus completing the circuit).

Teflon, other fluoropolymers, and polyethylene analogues have been mentioned as potential elastomeric materials. The applicant stated that insulation material used as guide sleeves between the anode and the titanium shell will be identified during the ISA process and will be capable of withstanding the environmental conditions of being submerged in the electrolyzer fluid. If appropriate, a maintenance/changeout frequency will be established, in accordance with Section 5.4.3 of the CAR, p. 5.4.10, regarding environmental design considerations and environmental qualification (EQ) requirements from the ISA.

The applicant identified the silicon nitride barrier and elastomeric materials as PSSCs—these represent passive engineered controls. In addition, the electrolyzer is geometrically safe from a criticality perspective, seismically designed (as per Section 11.12.3.3 of the revised CAR, which addresses B2 elements for seismic structural integrity), and can withstand turbulent flow without inducing vibration.

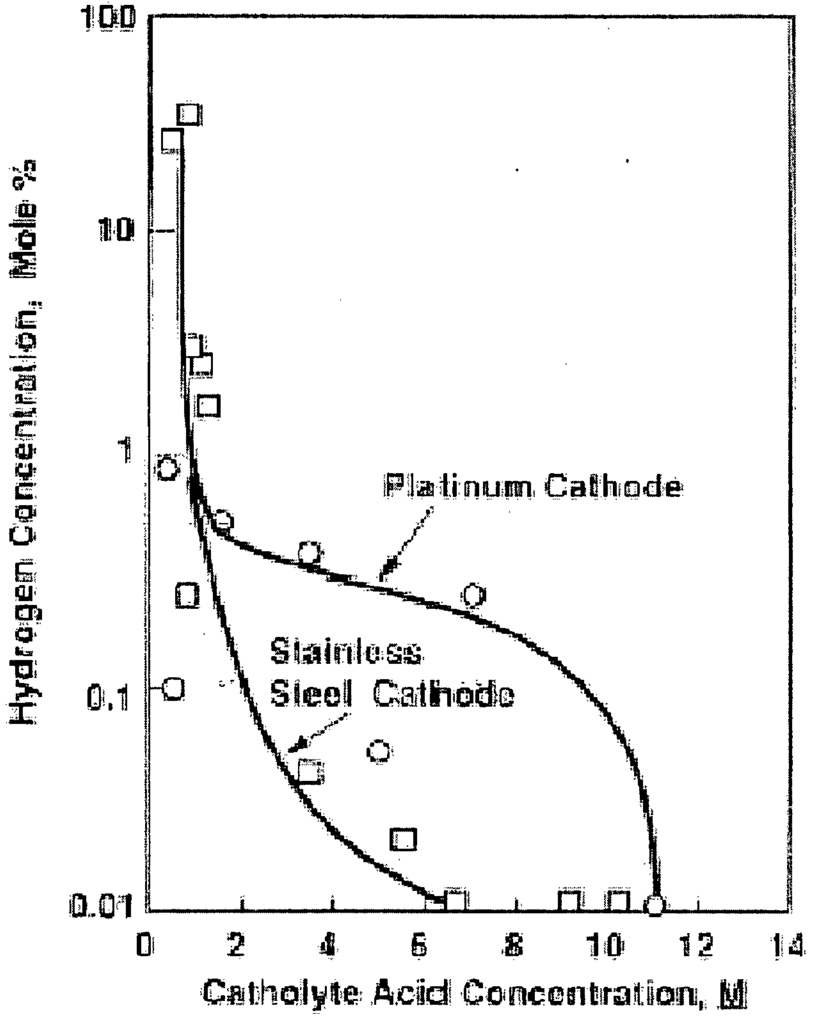

Figure 11.2-1 Acid Normality and Other Effects Upon Electrolytic Gas Generation

The applicant also noted that the nitric acid provides a liquid heat sink for cooling during operations, and that protection features exist to limit operations. There will be a current leakage detection system and a trip circuit on the rectifier, which represent the active engineered controls. The current leakage detection system is designed as a permissive signal and will stop the startup process (i.e., not allow the power to be turned on during startup) or cease operations (i.e., turn the power off to the electrolyzer) if the leakage current setpoint of 10 mA is exceeded. The trip circuit of the rectifier is another protective feature during operations. The rectifier normally supplies the electrolyzer with 400 A at 30 V. The trip setpoint is 420 A, and the rectifier is physically incapable of providing more than 900 A. The current leakage detection system and the trip circuit are part of the PSCS, an existing PSSC for active engineered controls.

The staff review finds that the overall safety strategy of prevention is appropriate given the postulated consequences.

Shutdown and Maintenance

The use of administrative controls that isolate power to electrolyzers during shutdown and maintenance is well established in the nuclear and chemical industries. In addition, there could be other requirements added to the procedures in the administrative control as a result of the ISA, such as hot-work limitations around titanium. However, these would be identified as part of any later DCS license application and would not change the fundamental strategy of using administrative controls. Thus, for the CAR stage, the PSSC of administrative control provides adequate assurances of safety and is acceptable.

Seismic Event During Operations

The electrolyzer structure is identified as the PSSC, with the safety functions of resisting seismic events (i.e., seisimically designed), withstanding turbulent flow, not inducing vibrations, and maintaining geometry for criticality purposes. This represents a passive engineered control. The applicant subsequently clarified seismic design in Section 11.12.3.3 of the revised CAR. In addition, the applicant confirmed that the function of the seismic trip system would include isolation of power to the electrolyzers. The seismic trip system represents an active engineered control (part of the PSCS PSSC) that is in addition to the seismic design of the electrolyzers. The trip system isolates power to the electrolyzers, thus removing the potential energy and root cause for a titanium fire event. The staff concludes the electrolyzer structure and seismic trip system are independent controls and, combined with the low initiating frequency of the seismic event, have the ability to achieve the very high reliabilities necessary to render the titanium event highly unlikely. Thus, the staff finds this approach acceptable.

Non-seismic Event During Operations

The applicant identified passive and active engineered controls. The engineered controls consist of the following:

- The first passive PSSC is the sintered silicon nitride barrier, with the safety function of physically separating the cathode from the anode in the nitric acid solution by serving as a dielectric barrier.

- The second passive PSSC is the polytetrafluoroethylene (PTFE, sometimes called Teflon) insulator, which has the two safety functions of providing insulation/separation between the cathode and anode structures, and providing insulation/separation between the anode and the ground.

- The third passive PSSC consists of the guide sleeves, which have the safety function of insulating/separating the anode from the titanium shell. The actual material would be identified by the applicant during the ISA process and would be capable of withstanding the environmental conditions associated with being submerged in the electrolyzer fluid. As appropriate, the applicant indicated that a maintenance/changeout frequency will be established and documented as part of any later license application DCS may submit.

- The fourth PSSC (active engineered control) is the PSCS, with the safety functions of detecting current leakage (shut down if the leakage exceeds the design basis of 10 mA) and tripping the rectifier circuit if the design basis current of 420 A is exceeded.

The staff notes that the applicant has committed to the EQ of electrical and mechanical components, as outlined in Section 11.11 of this FSER. The performance of elastomeric and ceramic materials as highly reliable passive engineered controls in the environment of the electrolyzer will be demonstrated during the license application phase, or the applicant will identify other PSSCs. Inspection, maintenance, and changeout frequencies would also be identified by the applicant as part of any later license application DCS may submit.

The active engineered control has direct analogues with electrolyzers in the industry. The staff review found that control/leakage current and control/maximum current control combinations are frequently used and can be designed and fabricated to meet the 10 CFR 70.61 performance requirements. The applicant will provide design information that implements the design basis in any subsequent license application it may later submit. However, the leakage design basis of 10 mA is consistent with the detection of small currents in the mA range. Instrumentation is available for detecting smaller currents than this, and current trip instrumentation is available for almost any amperage rating. The staff also has found that trip currents in the 5–10 mA range are generally used for trip instrumentation for the protection of industrial workers and the prevention of sparks and component damage. The staff anticipates that the actual design at the license application stage will involve consideration of protective device characteristics, such as let-through currents and time/temperature effects in the titanium resulting from electrical faults and arcing. Thus, the staff concludes that the applicant's proposed design bases are consistent with available ranges of values for the protection of industrial workers, in that sparks and component damage would be prevented. The design bases are thus found to be acceptable.

There is an interrelationship between the passive and active controls. The first active safety function detects leakage current, which essentially results from the initiation of failure mechanisms in the passive controls. Failure of the active leak current detection may not prevent the complete failure of one or more of the passive controls, which in turn would need the trip circuit to function. The staff notes that safety control systems can be designed and constructed such that safety monitoring and safety trip systems can be fully independent. Actual independence of the controls will have to be demonstrated by the applicant as part of any later license application DCS may submit.

In conclusion, the staff finds that the passive engineered controls appear capable of rendering the titanium event unlikely, and the separate active engineered controls also appear capable of rendering the event at least unlikely. In addition, the safety controls have the ability to be independent from each other and not subject to common mode failure. Therefore, the combination of passive and engineered controls proposed by the applicant should be capable of rendering the event highly unlikely, and this is acceptable for the CAR stage. The staff further notes that the applicant may develop additional information and submit it as part of its later license application, demonstrating that an electrical-induced titanium fire is not credible or is highly unlikely. This closes Open Item AP-03 from the staff's revised DSER (NRC, 2003c).

11.2.1.3.5 Loss of Confinement of Process Solutions

The applicant discussed the control strategy for leaks and loss of confinement of process solutions in process cells and outside gloveboxes in Sections 5.5.2.1.6.2 and 5.5.2.1.6.11 of the revised CAR. In the revised CAR, the applicant identified a control strategy for loss of confinement events (leaks) of AP process vessels and pipes in process cells based on mitigation. This control strategy uses the process cell to protect the worker, and it uses the associated ventilation system to protect the site worker, the IOC, and the environment. The applicant intended to contain fluid leaks within the cell, and any airborne contamination would be treated with HEPA filtration before exhaust. For facility workers, 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 PSSC of the process cell has the safety function of containing leaks within the cell. The actual fluid leaks would not be prevented.

The process cell exhaust (ventilation) system is identified as the PSSC for protecting the site worker, the IOC, and the environment with the safety functions to provide filtration to limit the dispersion of radioactive material and to ensure that a negative pressure exists between the process cell areas and the C2 areas of the facility.

The staff review identified a potential event involving an acute chemical exposure to the facility, site workers, and the IOC 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 because of erosion/corrosion of the vessels and piping. As discussed in Section 8.1.2.4.1 of this FSER, the applicant proposed controls for chlorine and nitrogen tetraoxide. Potential liquid phase leaks 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 nitric oxide 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.

The applicant indicated that the distance from the point of one of these in-cell releases to the worker is approximately equal to the 100-meter distance to the site worker; therefore consequence estimates of such releases for the site worker should bound any consequences for the facility worker (NRC, 2003a). The staff agrees with this qualitative distance analysis. This closes part of Open Item AP-13 from the original DSER (NRC, 2002b). However, for 379–757 L (100–200 gal) of radioactive nitrate solutions, IOC limits could be exceeded for several hundred meters. Some of the solutions might be at temperatures above ambient which could result in worker limits being exceeded for larger distances. Thus, the performance requirements of 10 CFR 70.61(b)(4) and 10 CFR 70.61(c)(4) might not be met. This potentially impacts the dissolution, dechlorination and dissolution, oxalic precipitation and oxidation, oxalic mother liquor, acid recovery, and liquid waste reception units. As discussed in Section 8.1.2.4.1 of this FSER, the applicant used lower airspeeds with a velocity-dependent evaporation model; some of the airspeeds are as low as 0.01 m/s (0.033 ft/s) (for comparison, a slight breeze is 1–2 m/s (3.3–6.6 ft/s)). As discussed in Section 8.1.2.4.1 of this FSER, the applicant has committed to a low chemical consequence limit and, if necessary, will identify planned features as IROFS to address the safety concern as part of any later license application it may submit. The staff concludes that this is an acceptable strategy, and Open Items CS-5b and AP-13 from the revised DSER (NRC, 2003c) are now closed.

The applicant identified a prevention strategy for process leaks in a C3 area outside of a glovebox. The PSSC is double-walled pipe for containing process fluids, and this protects the facility worker and the environment. The design basis is the fluid transport system (FTS), identified in Section 11.8.7 of the revised CAR. No PSSCs are anticipated for the site worker and the IOC because the estimated consequences are below the performance requirements of 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material." However, any release would be mitigated by the C3 ventilation system.

The staff review finds that this approach relies upon practices and codes and standards typically used in the nuclear and chemical process industries to control similar hazards. By analogy, the approach should have the ability to address the potential concerns and is acceptable to the staff.

11.2.1.3.6 Oxalic Precipitation Concerns (KCA)

The applicant identified six categories of hazard events associated with the oxalic precipitation and oxidation 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 Chapter 5 of this FSER.

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 for 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 design does not rely on concentration control to prevent a nuclear criticality in this unit and that the unit's calciner uses oxygen. The applicant has committed to standards for oxygen use and furnace applications (see Section 11.9.4 of the revised CAR). 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 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 discussed in Section 11.9 of this FSER.

Nitrogen cooling is identified as a means to extend bearing life; confinement is provided by the PSSC of the C4 confinement system.

As discussed in Section 8.1.2.4.1 of this FSER, the applicant proposed a control strategy for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. Such a loss of confinement would result in an untreated flowpath (bypassing the offgas treatment system) for chemical releases from the nitric acid solutions, nitrate/oxalate mixture, and calciner gases. But any release of potentially hazardous chemicals from the calciner area would likely be bounded by potential releases from tanks in process cells because the source term in the process cell tanks would be larger. The staff finds that the applicant's proposed control strategy is acceptable.

The applicant identified a design basis for the plutonium dioxide powder produced by oxalic acid precipitation and oxidation. Without controls, the oxide powder may be substoichiometric or have entrained or absorbed solutions subject to radiolysis and thus be pyrophoric and present a hazard. The applicant proposed controls, which are discussed and evaluated below in Section 11.3.1.2.3.

11.2.1.3.7 Oxalic Mother Liquor Recovery

Prior experience with evaporators indicates the potential for the unintended accumulation of either solvent or plutonium, or both. The accumulation of material can result from changes in system chemistry (WVNS, 1999). Such unintended accumulation can pose the hazards of (1) inadvertent criticality, (2) erosion-corrosion from accumulated solids, and (3) the potential for red-oil events.

The applicant identified six categories of hazard events associated with the oxalic mother liquor recovery 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 Chapter 5 of this FSER.

The staff notes that the applicant's description mentions acidification of the residual mother liquors in order to avoid the precipitation and unanticipated accumulation of residual plutonium by the oxalate. This indicates a potential 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. A control strategy, PSSCs, and design bases have been identified for hazardous chemical releases from the potential loss of confinement of radioactive materials in this unit. At a minimum, this applies to the following:

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

Section 8.1.2.4.1 of this FSER discusses the potential chemical releases from loss of confinement events. The staff finds that the control strategy and its related PSSCs and design bases constitute an acceptable approach.

11.2.1.3.8 Acid Recovery Unit

The acid recovery 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, "Standards for Protection Against Radiation," and will be reviewed as part of the review of any later license application DCS may submit.

11.2.1.3.9 Offgas Treatment Unit

The applicant identified the offgas treatment unit as a PSSC with the safety function of providing an exhaust path for the removal of gases in process vessels (Section 5.6 of the revised CAR).

Mechanical design bases are identified in Section 11.4.11.1.11 of the revised CAR. These include the following:

- two stages of HEPA filters
- spark arrestors and prefilters in each final filtration assembly
- each HEPA stage field tested to have an efficiency of 99.95 percent
- fire-rated dampers between designated fire areas
- in-place HEPA filter testing capability in accordance with ASME N510, "Nuclear Power Plant Air Cleaning Units and Components," issued 1980 (ASME, 1980), for the final filtration assemblies
- final filters and ductwork remain structurally intact during and after design basis earthquakes and withstand the effects of tornados

The staff requested information on the filtering line. The applicant provided additional information and identified the following design features of the offgas unit (DCS, 2001; RAI 142; Sections 11.3.2.11 and 11.3.2.13 of the revised CAR):

- Bubbling air scavenges tank ullage to maintain hydrogen concentrations at 1 percent or less.
- The system operates below the flash point of solvent vapors.
- Supplemental air is added to the system in order 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 offgas system handles vapors and gas mixtures that are potentially combustible in air streams, such as hydrogen, hydrazine, and TBP/dodecane (the solvent/diluent mixture—dodecane will likely be a petroleum distillation fraction and its constituents are more volatile than TBP). The applicant identified a setpoint/design basis/safety limit of 25 percent of the LFL in air for hydrogen (DCS, 2001; DCS, 2002f, RAI response 142). In RAI response 122 (DCS, 2001, 2002e), the applicant also identified a limit of 25 percent of the LFL for hydrogen in air from radiolysis in vessels containing plutonium. The staff notes that a limit of 25 percent of the LFL in air is routinely used by designers and operating facilities and is embodied in codes and standards. The applicant subsequently identified a design basis limit for hydrogen and other flammable gases and vapors, based on NFPA 69. This is discussed in Section 11.2.1.3.3 of this FSER. This should maintain potentially flammable gases and vapors at safe concentrations below their LFLs at all times, with adequate margin, and thus satisfactorily addresses the staff concerns. Consequently, Open Item AP-08 from the revised DSER is now considered closed (NRC, 2003c).

In response to RAI 142 (DCS, 2002f), the applicant did not identify temperatures below the flashpoint of solvent vapors. However, the applicant identified a safety strategy using a commitment to NFPA 69. This is discussed and found to be acceptable in Section 8.1.2.5 of this FSER. Consequently, Open Item AP-09 from the revised DSER is now considered closed (NRC, 2003c).

The process handles gases and vapors that are potentially reactive and toxic, such as nitrogen tetraoxide, nitric acid, nitric oxide, and hydrazine. The unplanned evolution of these gases—from and through radioactive solutions—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 addition, the applicant identified the removal of hazardous chemicals as a function of the offgas unit for protection of the HEPA filters (DCS, 2003a; NRC, 2003b). As discussed in Section 8.1.2.3.1 of this FSER, the applicant has agreed not to exceed low chemical consequence levels (see Tables 8-5 and 8-7). In addition, the offgas system includes components that have the ability to remove potentially toxic and reactive gases. In order to maintain the confinement barrier, the applicant implemented administrative controls to replace HEPA filters, such as those in the offgas system, after identified exposures to water or chemicals (DCS, 2003e). Therefore, the staff concludes that the applicant has provided strategies and design bases that have the ability to address the safety concerns regarding the offgas system, and this is acceptable for the CAR stage. Consequently, Open Item AP-10 from the revised DSER has been adequately addressed and is now considered closed (NRC, 2003c).

11.2.1.3.10 Corrosion Control (KDB and KDD)

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. In a letter to the NRC, the applicant mentioned the use of stainless steel to resist corrosion in the offgas system and the use of acid resistant materials in the HEPA filters (DCS, 2001). The applicant proposed a generic corrosion control program as a PSSC. This appears to be based on general corrosion. The pitting corrosion that could occur from silver (II) ions might not be detected before failure by the proposed PSSC of a general corrosion control program; therefore, the potential exists for the corrosion leak to release plutonium compounds (i.e., a loss of confinement).

Corrosion-resistant materials would be needed to maintain confinement of radioactive and chemical species. The revised CAR identifies two administrative PSSCs that apply to corrosion. The first is chemical safety control. One of its safety functions is to ensure control of the chemical makeup of the reagents and to ensure segregation/separation of vessels/components from incompatible chemicals (i.e., planned corrosion exposures). The second PSSC involves the Material Maintenance and Surveillance Programs (Sections 5.5.2.1.6.2 and 5.6.2.4 of the revised CAR). The safety function of this PSSC is to detect and limit the damage resulting from corrosion and thus mitigate the effects to the facility worker and the environment. As discussed in Section 5.6.2.4 of the revised CAR, this PSSC can identify corrosion problems within the facility before the occurrence of catastrophic failures.

The administrative PSSCs are not required to prevent corrosion that could result in small leaks. Small is not defined but inferred to be a small percentage of inventory. However, the staff concludes that the design basis function of the corrosion function of the FTS PSSC should address instrumentation and/or monitoring of components that could be exposed to aggressive species in the offgas and other units and thus address small leaks. The FTS design bases are discussed in more detail in Section 11.8 of this FSER. Specific details would be provided in any later license application DCS may submit.

The staff concludes that this information on corrosion controls provided in the revised CAR follows established codes and practices in similar industries, has the ability to address the potential safety concerns, and, consequently, adequately addresses the staff's concerns about corrosion monitoring for preventing major failures. The staff finds this to be acceptable for the CAR stage. Therefore, Open Items AP-04 and AP-11 from the revised DSER have been adequately addressed and are now considered closed (NRC, 2003c).

11.2.1.3.11 Liquid Waste (KWD)

In Section 10.1.4 of the revised CAR, the applicant discussed waste minimization and waste management. Liquid and solid wastes produced at the proposed facility will be transferred to SRS for processing and disposal. The applicant has worked closely with SRS during the facility design phase and provided SRS with waste characterization information. The SRS has reviewed and evaluated the information in the context of the existing WAC. The applicant is committed to meeting the SRS WAC or providing a stream that qualifies for a WAC deviation and exemption. The WAC for the SRS waste solidification building has not been issued, but the applicant stated that the interface between it and SRS will ensure that the waste solidification building is designed to manage the facility high alpha waste stream and the depleted uranium stream. This was part of Open Item AP-05 in the original DSER. This portion of Open Item AP-05 (now designated as AP-05a) is considered closed.

The applicant stated that the alkaline waste stream will be acidified in a separate neutralization tank before being mixed in the high alpha waste tanks. Neutralization and acidification are 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. Because the solubility limits of azides in alkaline media are lower, the alkaline media is acidified in order to increase the solubility limits. This ensures that the azides do not precipitate and create an explosion potential. Chapter 8 of the revised CAR and supplemental information provided by the applicant identify pH control as serving a safety function. Section 8.1.2.5 of this FSER provides further discussion of azide formation and an evaluation of the controls proposed by the applicant.

The applicant identified the high alpha activity and stripped uranium waste transfer lines as PSSCs (CAR Sections 5.5.2.3.6.5 and 10.5.2). These are double-walled stainless steel pipes that are seismically qualified and designed for leak detection and collection. The lines will be designed to accommodate mechanical and seismic loads. For load-handling events, the safety strategy relies on prevention. The PSSCs are the waste transfer lines. The safety function is to protect the lines from activities taking place outside the MFFF building. For external events (e.g., external fires, explosions, extreme winds, tornadoes, missiles, rain, and snow/ice loadings), the safety function is to prevent damage to the line. The design basis for both functions is ASME B31.3, "Process Piping," issued 1998 (ASME, 1998). This standard requires consideration of loads in the design of piping. The staff analysis notes that the code, the proposed approach with the waste transfer lines (i.e., double walled with leak detection), and the prevention strategy provide reasonable assurance that the design will not be damaged and release radionuclides outside of the MFFF building. The staff finds this to be acceptable. This item, identified as Open Item AP-06, is now closed.

The staff notes that an explicit inventory limit on waste is not specified in the revised CAR. Currently, the facility is designed to accommodate up to 90 days equivalent of most waste solutions (e.g., of the values in Table 11.2-1, because the storage of the LLW destined for the waste solidification building will likely be less than 90 days equivalent), although the applicant anticipated that there will be transfers of liquid wastes every 2 weeks. The applicant indicated that the facility will shut down before exceeding the liquid waste storage capacity. The staff interprets this to mean active waste generating operations would be curtailed at some setpoint before the tankage is completely full, until the potential backlog of waste at the facility is cleared. Actual setpoints would be defined by DCS as part of any license application it may later submit. The staff finds this approach acceptable for construction authorization.

[Text removed under 10 CFR 2.390]

Both are bounded by the safety assessment; therefore the staff finds this to be acceptable for the construction authorization. This item, identified as Open Item AP-05a, is now closed.

11.2.1.3.12 Sampling Systems

Table 11.3-34 in the revised CAR categorizes the sampling systems. Section 11.11 of the revised CAR provides information on the laboratory and indicates that a significant number of samples are required. The staff notes that laboratory personnel will most likely conduct the sampling. The applicant provided information on a PSSC entitled laboratory material controls that limits quantities of hazardous and radioactive materials in the laboratory. Section 5.6.2.7 of the revised CAR also states that procedures will be developed to establish limits on sample size and to ensure that laboratory operations are performed in accordance with safe laboratory operating practices. The staff finds that the outline of the sampling approaches appears to follow typical practices used in the chemical and nuclear industries.

In addition, DCS indicated that all sampling, with the exception of samples with very low levels of radioactivity, will be conducted within gloveboxes, and that there are no bag-in/bag-out operations because the sample containers would be pneumatically transferred from stations within the gloveboxes to the laboratory. The revised CAR identifies gloveboxes as PSSCs, with the safety function of maintaining confinement integrity for design basis impacts (Section 11.4.11.2). Laboratory material controls address the handling of the samples within the laboratory. Only the LLW samples would not be handled within gloveboxes; qualitatively, the staff concludes this does not present a challenge to the performance requirements of 10 CFR 70.61, "Performance Requirements." The staff finds that the applicant has identified PSSC and design basis information and finds that this issue has been adequately addressed for the construction authorization stage. This closes Open Item AP-12.

11.2.1.4 Design Basis of the PSSCs and Applicable Baseline Design Criteria

The plutonium isotopic composition design basis for AFS and PDCF/ARIES feeds is identified by the applicant as follows (see Section 11.3.7 of the revised CAR):

- ^{236}Pu < 1 ppb, at the origin of pit
- ^{238}Pu < 0.05%
- 90% < ^{239}Pu < 95%
- 5% < ^{240}Pu < 9%
- ^{241}Pu < 1% during lifetime of plant
- ^{242}Pu < 0.1%

The feed chemical impurities design bases were identified by the applicant and are listed in Tables 11.2-2 and 11.2-3 of this FSER. The radionuclide impurities design bases are listed in Table 11.2-4.

The americium content design basis for PDCF/ARIES feed material is identified by the applicant as follows:

$$\frac{^{241}\text{Am}}{\text{Pu total} + {}^{241}\text{Am}} \quad < 0.7\% \text{ during the lifetime of the plant}$$

The feed plutonium dioxide powder to the AP process in the facility has a maximum density of less than 7 g/cc. Plutonium dioxide powder entering the facility can have a density up to 11.46 g/cc. Therefore, after receipt and storage, a density measurement is made. If necessary, a milling step is performed to ensure the density is below 7 g/cc.

The applicant stated that feed materials which have an impurity content that exceeds a value listed in Tables 11.2-2, 11.2-3, and 11.2-4 can, in some cases, be processed at the proposed facility. The applicant will evaluate these batches for safety before accepting them for processing at the facility.

The staff noted that these parameters and the values listed in Tables 11.2-2, 11.2-3, and 11.2-4 for the plutonium feed to the facility may affect the design and the safe operation of the facility. The applicant identified these as design bases. The PSSC is chemical safety controls, and the safety function is to "ensure control of the chemical makeup of the reagents and ensure segregation/separation of vessels/components from incompatible chemicals." According to the staff review, this is an administrative control based on the analysis of the feed to the facility. The staff also concludes that exceptional batches of plutonium dioxide that have impurity contents exceeding the design bases will be evaluated according to the facility change process in 10 CFR 70.72. The staff concludes that this approach provides assurance that the design basis plutonium feed parameters will not be exceeded and finds this to be acceptable for the construction authorization stage. Consequently, this part of Open Item AP-07 from the revised DSER has been adequately addressed and is now considered closed (NRC, 2003c). Section 11.2.1.3.1 of this FSER discusses closure of the other part of AP-07.

The applicant stated that the BDC specified in 10 CFR 70.64(a) are incorporated into the design and operation of the facility (Section 5.5.5.4 of the revised CAR). The applicant stated that information demonstrating compliance with these criteria is provided in the applicable chapters of the revised CAR. For chemical protection, 10 CFR 70.64(a)(5) states the following:

> Chemical protection. The design must provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.

The applicant stated that reagents would be stored, and chemical mixtures would be prepared, in the reagent processing building and the reagent storage area of the AP area, and they are generally separated from each other and from radioactive materials. The applicant will avoid mixing incompatible materials by design, controls, and procedures. The AP and MP facilities are broken down into process functional units, which are made up of one or more subassemblies performing consistent and elementary tasks. The applicant stated that the breakdown into control functional units allows each entity to be operated relatively independently in the given operating mode (DCS, 2002e). The staff review notes that this separation and independence are consistent with accepted practices for safe operations.

The applicant will control process storage and operation conditions in order to prevent exothermic and potential autocatalytic reactions in the reagent processing building, as well as in the AP and MP areas. Autocatalytic and exothermic reactions of chemicals would be prevented through control of the process parameters (e.g., reactant concentration, temperature, catalyst concentration in solution, and pressure) that affect the reactions. Many of these controls have been identified as PSSCs with design bases. Codes and standards have been applied on a specific level, often as design bases (DCS, 2002e).

The applicant stated that there is reasonable assurance that the PSSCs will be sufficiently reliable and available based on the use of standard nuclear industry engineering practices. These practices are incorporated into the facility general design philosophy, design bases, system design, and commitments to applicable management measures. These practices ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and PSSCs will be appropriately maintained (DCS, 2002e).

The staff review finds that the applicant has provided sufficient information to meet the requirements of 10 CFR 70.64(a)(5).

Related to chemical protection, the explosion protection BDC is stated as part of the fire protection BDC in 10 CFR 70.64(a)(3):

> Fire protection. The design must provide for adequate protection against fires and explosions.

The applicant stated that there is reasonable assurance that the PSSCs will be sufficiently reliable and available based on the use of standard nuclear industry engineering practices. These practices are incorporated into the facility general design philosophy, design bases, system design, and commitments to applicable management measures. These practices ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and PSSCs will be appropriately maintained.

Table 11.2-2 Design Basis for Chemical Impurities in PDCF Feed Plutonium Dioxide

Chemical Component	Maximum Content (µg/g Pu)	Maximum Exceptional Content (µg/g Pu)	Chemical Component	Maximum Content (µg/g Pu)	Maximum Exceptional Content (µg/g Pu)
Ag	NA	10,000	Mg	500	10,000
Al	150	10,000	Mn	100	1,000
B	100	1,000	Mo	100	1,000
Be	100	2,500	N	400	400
Bi	100	1,000	Na	300	10,000
C	500	1,500	Nb	100	3,500
Ca	500	10,000	Ni	200	2,500
Cd	10	1,000	P	200	1,000
Cl	(+F < 250)	500	Pb	200	1,000
Co	100	10,000	S	250	1,000
Cr	100	500	Si	200	200
Cu	100	500	Sm	2	1,000
Dy	1	1,000	Sn	100	2,500
Eu	1	1,000	Ti	100	2,500
F	(+Cl < 250)	350	Th	100	100
Fe	500	2,500	V	300	2,500
Ga	12,000	12,500	W	200	2,500
Gd	3	250	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	18,837	

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 applicant stated that the BDC specified in 10 CFR 70.64(a) are incorporated into the design and operation of the facility (Section 5.5.5.4 of the revised CAR). The applicant further stated that information demonstrating compliance with these criteria is provided in the applicable chapters of the revised CAR. For chemical protection, 10 CFR 70.64(a)(5) states the following:

> Chemical protection. The design must provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the

Table 11.2-3 Design Basis for Chemical Impurities of AFS Plutonium Dioxide Feed Material

Chemical Component	Maximum Content for most (~75%) of Items (µg/g Pu)	Maximum Content exceeded only by 2% of Items (µg/g Pu)	Chemical Component	Maximum Content for most (~75%) of Items (µg/g Pu)	Maximum Content exceeded only by 2% of Items (µg/g Pu)
Ag	NA	10,000	I	NA	100
Al	4,000	15,000	In	20	2,500
Am	7,000 (100% ^{241}Am)	7,000 (100% ^{241}Am)	K	220,000	(Ca+K+Mg+Na) ≤40% Net weight
As	NA	100	La	NA	5,000
Au	NA	100	Li	5,000	10,000
B	100	1,000	Mg	70,000	(Ca+K+Mg+Na) ≤40% Net weight
Ba	5,000	10,000	Mn	1,000	2,000
Be	100	5,000	Mo	100	(Mo+Zr)<5,000
Bi	1,000	1,000	N	400	5,000
C	2,000	10,000	NO_3	NA	5,000
Ca	120,000	(Ca+K+Mg+Na) ≤40% Net weight	Na	130,000	(Ca+K+Mg+Na) ≤40% Net weight
Cd	1,000	1,000	Nb	100	3,500
Ce	NA	500	Ni	5,000	15,000
Cl	200,000	330,000	Np	500	1,000
Co	5,000	10,000	P	1,000	(P+S)≤10,000
Cr	3,000	8,000	Pb	200	5,000
Cu	500	3,000	Pd	NA	100
Dy	NA	NA	Pt	NA	100
Er	NA	500	Rb	100	5,000
Eu	NA	NA	S	330	(P+S)≤10,000
F	1,000	7,000	SO_4	1,000	(P+S)≤10,000
Fe	5,000	18,000	Sb	NA	100
Ga	12,000	15,000	Si	5,000	10,000
Gd	250	250	Sm	NA	NA
Ge	NA	100	Sn	1,000	10,000
Hf	50	1,000	Sr	5,000	10,000
Hg	NA	100	Ta	4,000	10,000

Table 11.2-3 (cont): Design Basis for Chemical Impurities of AFS Plutonium Dioxide Feed Material

Chemical Component	Maximum Content for most (~75%) of Items (μg/g Pu)	Maximum Content exceeded only by 2% of Items (μg/g Pu)	Chemical Component	Maximum Content for most (~75%) of Items (μg/g Pu)	Maximum Content exceeded only by 2% of Items (μg/g Pu)
Ti	100	3,000	V	300	1,000
Th	100	300	W	4,000	10,000
Tl	NA	100	Y	200	10,000
Enriched Uranium (EU)	EU≤30% Net weight	EU≤30% Net weight Annual max. value—50 kg (110 lbs) (^{235}U—93.2%)	Zn	1,000	10,000
Depleted Uranium, Natural Uranium	[TBD]	500,000	Zr	50	(Mo+Zr)≤5,000

safety of licensed material, and hazardous chemicals produced from licensed material.

The applicant stated that reagents would be stored, and chemical mixtures would be prepared, in the reagent processing building and the reagent storage area of the AP area, and they are generally separated from each other and from radioactive materials (DCS, 2002e). The applicant intends to avoid mixing incompatible materials by design, controls, and procedures. The AP and MP facilities are broken down into process functional units, which are made up of one or more subassemblies performing consistent and elementary tasks. The applicant stated that the breakdown into control functional units allows each entity to be operated relatively independently in the given operating mode (DCS, 2002e). The staff review notes that this separation and independence are consistent with accepted practices for safe operations.

The applicant will control process storage and operation conditions in order to prevent exothermic and potential autocatalytic reactions in the reagent processing building and in the AP and MP areas. Autocatalytic and exothermic reactions of chemicals would be prevented through control of the process parameters (e.g., reactant concentration, temperature, catalyst concentration in solution, and pressure) that affect the reactions. Many of these controls have been identified as PSSCs with design bases (DCS, 2002e). Codes and standards have been applied on a specific level, often as design bases.

The applicant stated that there is reasonable assurance that the PSSCs will be sufficiently reliable and available based on the use of standard nuclear industry engineering practices. These practices are incorporated into the facility general design philosophy, design bases, system design, and commitments to applicable management measures. These practices ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and PSSCs will be appropriately maintained (DCS, 2002e).

Table 11.2-4 Radionuclide Impurities in the Feed Plutonium Dioxide

PDCF Type

Impurity	Isotope	Maximum Content µg/g Pu
Americium	^{241}Am—100%	7,000 µg/g Pu (Note 1)
Uranium (HEU)	^{235}U—93.2%	Standard value—5,000 µg/g Pu Maximum value—20,000 µg/g Pu for 10% of the delivered cans during 1 year Annual maximum value = 17 kg (37 lbs) (Note 2)
(1) At the plutonium design basis feed rate of 3.5 MTHM/yr, the americium annual quantity becomes 24.5 kg/yr (54 lb/yr). (2) The uranium standard maximum value corresponds to 17.5 kg/yr (39 lb/yr), while 10% at 20,000 and 90% at 5,000 (micrograms U/g Pu) correspond to 22.75 kg/yr (50 lb/yr).		

AFS Type

Impurity	Isotope	Maximum Content µg/g Pu
Americium	^{241}Am—100%	11,000 µg/g Pu
Enriched Uranium	^{235}U—93.2%	Maximum value—30% of can net weight Annual maximum value = 50 kg (110 lb)
Depleted Uranium and Natural Uranium	^{238}U	Maximum value—42% of can net weight (with 5% of enriched uranium)

The staff review finds that the applicant has provided sufficient information to meet the requirements of 10 CFR 70.64(a)(5). Using the SRP, the staff review notes that the previously identified open items in AP have been closed by additional safety strategies and information from the applicant, and the staff concludes that the applicant has satisfied this BDC.

Related to chemical protection, the explosion protection BDC is stated as part of the fire protection BDC in 10 CFR 70.64(a)(3):

> Fire protection. The design must provide for adequate protection against fires and explosions.

The applicant states that there is reasonable assurance that the PSSCs will be sufficiently reliable and available based on the use of standard nuclear industry engineering practices. These practices are incorporated into the facility general design philosophy, design bases, system design, and commitments to applicable management measures. These practices ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and PSSCs will be appropriately maintained (DCS, 2002e).

The staff review finds the applicant has now provided sufficient information to meet the requirements of 10 CFR 70.64(a)(3). Using the SRP, the staff review notes that the previously identified open items related to MP have been closed by additional safety strategies and information from the applicant, and the staff concludes that the applicant has now satisfied this BDC.

11.2.2 Evaluation Findings

In Section 11.3 and Chapters 5, 8, and 11 of the revised CAR, DCS provided design basis information for chemical process safety PSSCs identified for the proposed facility. Based on the staff's review of these revised CAR chapters and on supporting information provided by the applicant that is relevant to AP and chemical process safety, the staff finds that, for the reasons discussed above, DCS has now met the BDC set forth in 10 CFR 70.64(a)(3) for explosions, and 10 CFR 70.64(a)(5) for chemical safety. Further, the staff concludes, 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.

Several previously identified open items in the April 30, 2002, and the April 30, 2003, DSERs have now been closed in a satisfactory manner—AP-02, AP-03, AP-07, AP-08, AP-09, and AP-10.

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