FINAL SAFETY ANALYSIS REPORT

SAVANNAH RIVER SITE

DEFENSE WASTE PROCESSING FACILITY

VOLUME 5

NOVEMBER 2018
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November 2018
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6.0 INTRODUCTION

The Defense Waste Processing Facility (DWPF) is part of an integrated waste treatment system at the Savannah River Site (SRS) to treat wastes containing radioactive contaminants. Figure 1.4-1 illustrates the relationship between DWPF and the other waste process areas.

6.0.1 WASTE CHARACTERIZATION

Since startup of the F and H chemical separation areas in 1954, about 83 million gallons of aqueous radioactive wastes have been generated from reprocessing of irradiated reactor materials. Waste management campaigns have reduced this volume, primarily by evaporation and concentration. It is planned to complete the process by solidifying the current SRS waste inventory, about 35 million gallons, at the DWPF. There are three 221-S feed streams, a washed sludge slurry that is transferred from Tank 40 in H-Area, MST/Sludge Solids that are transferred from 512-S and Strip Effluent (SE) transferred from the Modular CSSX Unit (MCU) in H-Area. All of these streams are fed to 221-S via the LPPP. DWPF also sends a recycle waste stream to H-Area via the HDB8 Facility and a 512-S Filtrate stream from 512-S to MCU. The general compositions of the DWPF feeds and the recycle streams are shown in Table 6.1-1. The chemical composition of the design basis feeds are shown in Table 6.1-2 and Table 6.1-6 for the sludge slurry and MST/Sludge Solids. The nominal chemical composition of SE containing BOBCalix-based solvent (the original CSSX solvent) is shown in reference 28. The chemical composition of SE containing Next Generation Solvent (NGS) or a blended solvent (BOBCalix-based solvent and NGS) is shown in Reference 29. A minimum out-of-reactor aging period of five years (total) for sludge was chosen to reduce the impacts of short-lived radionuclides such as Ce-144 and Ru-106 on shielding requirements for the DWPF design.

6.0.1.1 High Level Waste

The radioactive acid waste from the separations processes in F-and H-Areas are made strongly alkaline with NaOH and nitrites added to minimize corrosion while stored in large underground tanks in the tank farms. Metal hydroxides and hydrated metal oxides (primarily iron, aluminum, manganese and actinides) form a sludge containing most of the radioactivity, which gradually settles. The water containing soluble salts is decanted into treatment tanks where it is concentrated by evaporation of the water, forming salt cake and reducing the volume of the stored wastes. The evaporated water is discharged after being treated in the Effluent Treatment Facility (ETF). These processes are described in Reference 1.

6.0.1.2 Sludge Slurry Feed

Before being fed to the DWPF, the waste sludge is washed with inhibited water to remove dissolved solids. The wash water is decanted and the settled sludge is transferred to tanks for storage until fed to the DWPF. The spent wash water from sludge washing is then concentrated by evaporation in the tank farms to produce salt cake and supernate.
6.0.1.3 MST/Sludge Solids

Salt waste from the tank farm is dissolved, potentially treated with monosodium titanate (MST) to adsorb soluble strontium and actinides and sent to 512-S to filter the solids. The insoluble solids are physically separated by crossflow filtration to produce a low activity (low actinide/high or low cesium) Filtrate and a high activity (high actinide) MST/Sludge Solids Stream. The high activity MST/Sludge Solids Stream is recycled to the LWPT and may be washed to adjust the sodium molarity to a point acceptable to 221-S and then the contents of the LWPT are transferred to 221-S for final treatment.

6.0.1.4 Filtrate

The Filtrate is transferred to MCU [the H-Area Cs-137 removal facility]. The Filtrate will be treated as required in MCU and transferred to Tank 50 (Decontaminated Salt Solution) and then on to the SPF for incorporation into grout.

6.0.1.5 Strip Effluent

The SE is produced in MCU as a Cs-137 concentrated stream from the Filtrate sent by 512-S. This stream is then transferred to the SEFT via jumpers in the LPPP-RPT and PPT Cells.

6.0.1.6 Chemical Compositions

The chemical composition of the design basis feeds for DWPF are shown in Tables 6.1-2 and 6.1-6. Characteristically, the feed coming to DWPF is hazardous because it is corrosive and contains mercury compounds; however, glass produced from these feeds is classified as non-hazardous radioactive waste material because the glass product meets the EPA classification requirements. The Sludge, MST/Sludge Solids and SE Streams contain no listed EPA hazardous wastes.

6.0.2 MISSION OF DWPF FACILITIES

As summarized in Chapter 1, the DWPF is designed to vitrify stored High Level Waste (HLW) characterized above. Three separate aqueous slurries of HLW are sent to 221-S for treatment: (1) sludge slurry generated from the Concentration, Storage, and Transfer (CST) Facility; (2) MST/Sludge Solids slurry from the Actinide Removal Process (ARP); and (3) SE slurry from CST Facility. The 221-S feeds are chemically treated, and the soluble and insoluble solids are melted with glass frit into a durable borosilicate glass. The glass is poured into stainless steel canisters and stored in one of the Glass Waste Storage Buildings until the canisters can be transferred to a federal repository for final disposal. A flow diagram of the integrated HLW treatment, storage and disposal operations at the SRS is shown in Figure 1.4-1. A block flow diagram of DWPF operations is illustrated in Figure 1.4-3.

Process flow diagrams, waste compositions, material flow rates, systems used to monitor process conditions, and systems used to control the process are described in this chapter. Potential hazards of the process systems and operations are also identified.
6.1 WASTE TREATMENT AND VITRIFICATION

The principal product of the DWPF process, borosilicate glass contained in a sealed canister, is constituted to satisfy the waste acceptance product specifications as documented in the DWPF Waste Form Compliance Plan, (Ref. 4). Process operations within Building 221-S are designed to convert the solids in washed sludge slurry (Sludge Feed) from H-Area, MST/Sludge Solids from 512-S and SE from H-Area into a waste form (glass), encapsulated in stainless steel canisters. Mercury is recovered as a byproduct of the process. Aqueous radioactive wastes from the various treatments within 221-S are collected, chemically adjusted with caustic and nitrite to reduce tank corrosion, and returned to the H-Area Tank Farm for further treatment. Liquid waste effluents from the process are not released directly to the environment if they do not pass a radiological screening; gaseous effluents from the process that contain radioactive particulates are decontaminated before they are discharged. The general compositions of the three slurry feeds and of the aqueous waste that is returned to H-Area are shown in Table 6.1-1.

The vitrification process is designed to be operated with sludge feed. This chapter 6 provides a general process description for this mode of operation. Because waste compositions vary, actual process conditions may differ from these process descriptions. Changes in process conditions, such as concentrations or quantities of process chemicals added, are allowed if tests using simulant and/or actual macro-batch feeds verify that combustible and/or oxidant concentrations are within design bases limits. Changes must also be confirmed by an approved USQ review. Process control parameters established through verification testing shall be controlled and used in conjunction with the general process descriptions.

Each major process operation is described in this chapter. Although the preparation of sludge slurry feed and SE sent to 221-S are not within the scope of the DWPF FSAR, these processes are described briefly to aid the understanding of the overall HLW treatment process at the Savannah River Site. The other process steps described in Section 6.1 are within the scope of this FSAR. Flow diagrams of the DWPF process and corresponding material flows are described in Section 6.2 and illustrated in Figures 6.1-1 through 6.1-12.

6.1.1 CHEMICAL HANDLING, STORAGE AND USE

Liquid and dry chemicals are used in the DWPF processes, in decontamination operations, and in wastewater collection and neutralization. Recovered liquid byproducts of reactions during treatment operations must also be collected and stored and gaseous reaction products must be controlled. The handling, storage and use of process chemicals and recovered byproducts of reactions are described in this section. Principal gaseous reaction products are also included.

Bulk liquid and dry chemicals are stored in the chemical storage areas located throughout the facility as described in Section 5.4.13. Potentially reactive materials are segregated. Also, solutions of potentially reactive chemicals are stored in tanks that are segregated by separate dikes. Vessel vent streams are vented and segregated to limit uncontrolled emissions and hazardous reaction products. Specific gaseous, solid and liquid chemicals used in the process.
are listed as process chemicals; the significant reaction products of the process are also listed. Both are described below. Potential hazards associated with these chemicals are also described. New applications of chemicals or use of new process chemicals may be required and are subject to the USQ process. FSAR Section 8.2, Industrial Hygiene, discusses the organization, programs, and practices applied at DWPF to regulate hazardous chemical usage.

6.1.1.1 Process Chemicals

PROCESS GASES

Argon

Argon is an inert gas used for welding, glass pool mixing (bubbling), melter level sensing and laboratory analytical equipment.

Helium

Helium is used in the Inner Canister Closure Station to leak test the temporary seal before a canister’s outer surface is decontaminated.

Nitrogen

Nitrogen gas is used in the DWPF and the 512-S for purging, blanketing, pressurizing, measuring, sampling and analyzing. Ambient vaporizers gasify stored liquid nitrogen at both facilities for delivery to users. Liquid nitrogen tanks with ambient vaporizers provide a backup nitrogen source for selected users. The nitrogen use points in the DWPF and 512-S are described in Section 5.4.14.

Acetylene

The acetylene system is abandoned in place.

Propane

Propane is supplied to the Analytical Facility on the mezzanine level of the 221-S Building. Propane is supplied by two banks of bottles in the compressed gas storage area.

DRY PROCESS CHEMICALS

Boric Acid

Boric acid may be used to adjust batches of melter feed (SRAT, SME or MFT) to meet waste glass product specifications. Administrative Control 5.8.2.23 must be implemented prior to use of boric acid to adjust melter feed batches. Boric acid is a crystalline powder that is chemically stable under ordinary conditions of storage and use.
Except through direct ingestion or inhalation, boric acid is not hazardous and normal industrial hygiene practices for handling chemicals will adequately protect workers from the solid or solutions. In the dry state, handling may generate nuisance dust that could irritate mucous membranes.

**Glass Frit**

Borosilicate glass frit is used as the principal additive to the SME to prepare melter feed and as a component of the slurry used to decontaminate exterior surfaces of canisters that contain radioactive contamination. Typically, large bins containing frit are received and stored in Building 422-S. Dry frit is transferred mechanically to the Frit Slurry Makeup Tank in Building 422-S to prepare an aqueous slurry containing frit and dilute formic acid. The slurry is pumped to the Process Frit Slurry Feed Tank located in the third floor operating gallery. Frit and water slurries are also prepared in the Decontamination Frit Slurry Feed Tank (DFSFT) in 221-S. Slurry from the DFSFT is used in the frit blasting process in the Canister Decontamination Cell (CDC).

Borosilicate glass frits are classified as inert materials under normal conditions of storage and use. Frit compositions may be modified to meet product specifications for certain waste blends that must be processed. The range of frit compositions for use in the vitrification process has no safety implications. Principal chemical components in the frit are silicon dioxide, boron oxide, and alkali metal oxides.

**Oxalic Acid**

Use of oxalic acid where sludge is present is restricted as described in Chapter 8.

At the 512-S, oxalic acid is stored in a nominal 6,000-gallon tank and transferred directly as needed for cleaning the crossflow filter and secondary filter. Oxalic acid may be received as a solid or as a liquid dissolved in water. It is stable at ordinary temperatures, moderately reactive with oxidants, slightly flammable but can react explosively with strong oxidizers. When dissolved in water, it reacts with bases and is corrosive. Oxalic acid is toxic and is a severe irritant to the eyes, mucous membranes and skin.

**Potassium Nitrate**

Potassium Nitrate is used to prepare solutions that are used to adjust melter feed slurry in the SRAT, SME or MFT. Potassium nitrate is corrosive and a skin and eye irritant.

**Potassium Permanganate**

Potassium Permanganate is used to prepare a solution for use in equipment decontamination. Because potassium permanganate is a powerful oxidizing agent, appropriate precautions are required to isolate it from organics and reducing agents to avoid an uncontrolled or violent reaction.
Sodium Nitrite

Solutions of sodium nitrite are added to the Recycle Collection Tank to inhibit the corrosiveness of neutralized waste. Sodium nitrite is a crystalline solid that is stable under normal conditions of storage and use. It can function as an oxidizing agent or a reducing agent. It reacts with acids and oxidizing agents to form nitrogen dioxide (Ref. 25). High concentrations of dust or mist from solutions may irritate the eyes and mucous membranes. Sodium nitrite is highly toxic by inhalation and toxic by ingestion.

LIQUID CHEMICALS AND SOLUTIONS

Formic Acid

Formic acid is received as a nominal 90 wt. % aqueous solution. Formic acid is used undiluted in the CPC to reduce mercury compounds and as a redox component. (Refer to Subsection 6.1.5.2). Dilute formic acid is also used in the preparation of aqueous slurries of frit. The Lower Flammability Limit (LFL) for formic acid is 18%, and the flash point is 50°C. Formic acid can react violently with oxidizing agents, such as nitric acid, evolving great amounts of heat and gas (hazards and accidents related to formic acid are discussed in Section 9.4).

Nitric Acid

Nitric acid is received as a nominal 50 wt. % solution. Nitric acid is used to acidify the sludge slurry in the SRAT and for pH and/or redox adjustment in the SME. It is also used to maintain the proper pH in the SMECT condensate used for scrub solution in the ammonia scrubbers (except for the SME scrubber where scrub solution is no longer supplied) and to decontaminate recovered mercury in the Mercury Purification Cell. Nitric acid may also be supplied to any aqueous processing tank in the CPC for purposes of decontamination or may be added to the MFT for Melter feed adjustments. Such additions are done under administrative control and require a spool piece change outside the CPC. Nitric acid is also provided to the Chemical and Industrial Waste Facility for waste neutralization of caustic solutions. Sump systems for tank overflow or leaks that could contain significant concentrations of nitric acid are isolated from formic acid and caustic. Vent systems that handle vapors from nitric acid are also isolated from the vent system that handles vapors from solutions containing formic acid. Nitric acid is very highly irritating to skin, eyes, and mucous membranes and is also a very strong oxidant.

Sodium Hydroxide

An aqueous solution of sodium hydroxide (caustic) is received at a nominal concentration of 50 wt. %. In 512-S, the caustic is stored in a tank with a nominal capacity of 6,000 gallons. Solutions of various concentrations are prepared and used in various operations in 512-S, such as feed adjustment or filter cleaning. In the Vitrification Building, sodium hydroxide is used in the RCT for waste neutralization or for pH adjustments in the CPC vessels. Sodium hydroxide is also used in the DWTT. Sodium hydroxide may be supplied to any aqueous processing tank in the chemical process cell for purposes of decontamination. Such additions
are done under administrative control and require a spool piece change outside the CPC. Feed tank vapors are vented, filtered, and discharged to the atmosphere. Sodium hydroxide is also provided to the Chemical and Industrial Waste Facility for waste neutralization of acidic solutions. Sodium hydroxide is corrosive, extremely irritating to the skin and eyes, and in concentrated solutions, can produce a strongly exothermic reaction with water and acids.

**Surfactants**

Surfactants used in DWPF processes (Reference 17) include antifoam agents to prevent foaming and subsequent carryover of radionuclides during processing. The antifoam agent is used in the CPC to reduce foam generation during boiling (Reference 17, 23, 24). These surfactants are eye irritants and may also be irritating to the skin.

**Monosodium Titanate**

Monosodium Titanate (MST) may be added to the 512-S feed in H-Area before it gets to 512-S. The ability to store and add MST in 512-S exists as an alternative that may be performed infrequently, when necessary. MST is received in the 512-S cold chemical feeds area as a nominal pre-mixed 15 wt. % solution. MST is a corrosive slurry consisting of MST (15%), small amounts of isopropyl and/or methyl alcohol (< 500 ppm), sodium hydroxide (0.6%), and water. Due to the small quantity of alcohol in the MST, a flammable condition in the Late Wash Precipitate Tank cannot occur once added to the vessel. MST is used as a striking agent for actinides and strontium sorption in the HLW salt solution. Contact with the eyes or skin may cause irritation. If the body comes in contact with the mixture, the affected area should be flushed with copious amounts of water. The total inventory of MST slurry that is anticipated to be stored within the 512-S at any time is approximately 4,000 pounds or 425 gallons.

6.1.1.2 **Reaction Products**

**GASES**

**Ammonia**

Ammonium ion is produced during the SRAT cycle through a reaction between formic acid and nitrate. To mitigate this potential hazard, packed bed scrubbers have been installed and may be utilized to treat the vapor effluents from the Sludge Receipt & Adjustment Tank (SRAT), the Slurry Mix Evaporator (SME), the Recycle Collection Tank (RCT) and the Melter Feed Tank (MFT). These scrubbers are designed to limit the concentration of ammonia in the vapor effluent in order to minimize shutdown time required to inspect and flush accumulated ammonium nitrate from the process vessel ventilation system piping (Reference 5). The scrubbers are not required for use during operations as the estimated annual accumulation of ammonium nitrate without the use of scrubbers is small and does not present a fire or explosion hazard (See Section 9.4.2). The condensate from SRAT and SME operations that accumulates in the Slurry Mix Evaporator Condensate Tank (SMECT) is used as scrub solution in the scrubbers (except for the SME scrubber where scrub solution is no
longer supplied) when the scrubbers are being utilized. Nitric acid can be added to the SMECT to maintain the proper pH of the scrub solution.

The SMECT contents are periodically transferred to the RCT, inhibited with caustic and sodium nitrite and transferred to the H-Area Tank Farm via the LPPP. Treatment with caustic in the RCT converts the ammonium ion to free ammonia but the scrubber on the vent from the RCT may be utilized to remove most of the ammonia from the RCT vapor effluent to minimize the ammonia concentration in the PVV system. Some ammonia is released into the LPPP PPV system from the Recycled Waste Pump Tank during the transfer of aqueous waste from DWPF to H-Area. The remainder is released into the vapor space of waste storage tanks in H-Area.

Carbon Monoxide

Carbon monoxide is generated in the vitrification process within the melter. Most of this carbon monoxide reacts with air in the melter plenum to form carbon dioxide. Although carbon monoxide is highly toxic, the concentration in vapor releases from operations is low and does not constitute a significant hazard in DWPF since it is diluted by the large Zone 1 air flow stream. Total annual permitted release of CO complies with the orders and standards listed in Section 7.1.1.

Hydrogen

Hydrogen gas is generated during melter feed preparation processes in the CPC primarily from dehydrogenation of formic acid catalyzed by noble metals. A small amount of hydrogen may also be generated from radiolysis of water from the various process streams, and from thermolytic decomposition of process stream constituents which can produce a negligible amount of hydrogen (Ref. 32). Hydrogen is flammable and can support combustion [the Lower Flammability Limit (LFL) for hydrogen in air is 4.0 vol%]. Hydrogen can also form explosive mixtures with air [the Lower Explosivity Limit (LEL) for hydrogen in air is 12.0 vol%]. Purge systems are designed to maintain sufficient purge to each vessel to limit the hydrogen concentration.

Nitric Oxide

Nitric oxide is a gas that may be formed during various waste treatment operations in 221-S. It is not flammable, but it will support combustion. The vapor is highly toxic and hazardous because of its ability to cause delayed chemical inflammation of the lungs that could lead to pulmonary edema. Nitric oxide oxidizes in air to form nitrogen dioxide, which is extremely reactive and is a strong oxidizing agent (see below).

Nitrogen Dioxide

Nitrogen dioxide is a gas with an acidic and suffocating odor that may be formed during various treatment operations in 221-S. It is not flammable, but it is a strong oxidizing agent and will support combustion. It reacts in water to form nitric and nitrous acids. The vapor is
a strong irritant to the pulmonary tract and is highly toxic because of its ability to cause delayed chemical inflammation of the lungs and pulmonary edema. Chronic or repeated exposure may cause a permanent decrease in pulmonary function. Purge systems also protect against hazardous accumulations of NO and NO₂.

**Antifoam Degradation Products**

Antifoam is routinely added to the SRAT and SME to minimize foaming and mitigate sludge carryover events. After addition, antifoam decomposes into flammable ADPs, including hexamethyldisiloxane (HMDSO), trimethylsilanol (TMS), and propanal. These ADPs may be present in the SRAT and SME from direct antifoam additions and in the MFT from SME slurry transfers. Additionally, ADPs are expected to be present in the condensate vessels (SMECT, RCT, RPT) as a result of carryover events or from ADPs condensing to the SMECT. These condensed ADPs would subsequently be transferred from the SMECT to downstream condensate vessels. Other degradation products may be present in very small quantities, or as transitional by-products of antifoam additions. When present in the liquid phase with process streams, ADPs can contribute to the radiolytic/thermolytic generation of hydrogen (Ref. 32).

**LIQUID REACTION PRODUCTS**

**Mercury**

Mercury is a highly toxic element present in the radioactive feeds from the Tank Farm to DWPF and the 512-S. It is chemically reduced, steam-stripped and collected in the Chemical Process Cell. When a sufficient volume of mercury has been collected, it is transferred to and purified in the Mercury Purification Cell (see Section 6.1.9 for details). Mercury emissions to the atmosphere are minimized by directing vents from vessels containing mercury through condensers cooled by chilled process cooling water.

Personnel protection during mercury purification is provided by performing washing operations on radioactively contaminated mercury in a remote shielded cell in the analytical facility. Final distillation may optionally be performed in a vented fume hood. Gases from the distillation and purification processes are vented to the CPC Cell.

**6.1.2 INTERAREA TRANSFERS**

Underground interarea pipelines are used to transfer HLW slurries between H-Area and DWPF. Similarly, a separate underground line is used to transfer aqueous radioactive waste generated in DWPF to the H-Area Tank Farm. They can also be used to transfer chemical simulants of waste slurries for use in the DWPF processes. The layout of the Interarea Transfer system, which includes the LPPP and the 512-S is shown in Figure 5.3-1.

Each slurry feed (Sludge, MST/Sludge Solids, and SE) is transferred to Building 221-S via the Low Point Pump Pit (LPPP). Sludge is transferred directly from H-Area to the LPPP for subsequent transfer to the Sludge Receipt Adjustment Tank (SRAT) located in the Chemical
Processing Cell (CPC) of Building 221-S. MST/Sludge Solids are transferred to the LPPP for subsequent transfer to the Precipitate Reactor Feed Tank (PRFT) located in the SPC. SE is transferred via jumpers in the LPPP-RPT and PPT Cells to the SEFT in the CPC.

Process vent systems are provided at the LPPP and 512-S to limit the release of radioactive materials, to control the atmosphere within the process tanks, and to limit radioactive particulate escape in the event of overpressurization. Details of these process vessel vent systems are discussed in Chapter 5.

6.1.2.1 Transfer of Radioactive Slurries

A process batch of washed sludge slurry is transferred from Tank 40 in H-Area to the LPPP and then to the SRAT located in the CPC. A process batch of MST/Salt Solution from HLW Tank Farm is transferred from H-Area to 512-S and filtered/ concentrated. The MST/Sludge Solids are then transferred from the LWPT in 512-S to the LPPP-PPT and then on to the PRFT located in the SPC of Building 221-S.

SLUDGE SLURRY TRANSFERS

Radioactive sludge slurry is transferred through the Sludge Pump Tank (SPT) in the LPPP to the SRAT. The chemical composition of the waste stream is listed in Table 6.1-2.

MST/SLUDGE SOLIDS TRANSFERS

MST/Salt Solution from the tank farm is sent to 512-S to be filtered for the removal of solids to lower the activity of the Salt Solution so that it may qualify to be sent to MCU. The Sr-90 and actinides, if adsorbed onto MST, are physically separated along with the entrained sludge solids by the crossflow filter. The MST/Sludge Solids Stream is transferred from the LWPT to the LPPP-PPT and on to the PRFT in the SPC. The chemical composition of the waste stream is listed in Table 6.1-6

RECYCLE WASTE TRANSFERS

The Recycle Collection Tank (RCT) is used to accumulate waste material from Chemical Process Cell operations. Batches of inhibited recycle waste are transferred from the RCT to the Recycle Pump Tank (RPT) in the LPPP and on to the HDB-8 Complex in H-Area. The nominal chemical composition of the Recycle Stream is listed in the Waste Compliance Plan, Ref. 21. In addition to the Recycle Stream resulting from the overheads from normal DWPF operation, the stream may also receive limited amounts of sludge and strip effluent from decontamination activities, sump transfers, and carryover events from the process vessels. Within the 512-S, wash water may be used to reduce the sodium concentration of the solids in the LWPT heel. This wash water is sent to the LWHT via the crossflow filter and transferred from the 512-S to Tank 50 after being transferred to MCU.

FILTRATE TRANSFERS

The Filtrate is transferred from the LWHT to MCU.
6.1.2.2 Design Transfer Conditions

WASHED SLUDGE SLURRY TRANSFER TO SRAT

- Nominal batch size: 3,000-3,500 gallons per transfer
- Transfer frequency: Once every 86 hrs (nominal, at design attainment)
- Transfer rate: 100 gpm (nominal)
- Solid content: 15 wt % (nominal)

RECYCLE WASTE FROM RCT TO H-AREA

- Nominal batch size: 7,500 gallons
- Transfer frequency: Two times every 24 hours (nominal, at design attainment)
- Transfer Rate: 120-140 gpm (nominal)

MST/SALT SOLUTION TRANSFER TO 512-S

- Nominal Batch Size: 3,800 gallons (nominal)
- Transfer Frequency: Once every 18 hours (nominal)
- Transfer Rate: 120 gpm (nominal)

MST/SLUDGE SOLIDS TRANSFER TO LPPP-PPT

- Nominal Batch Size: 950 gallons (nominal)
- Transfer Frequency: Upon obtaining 5 wt. % solids in the LWPT (nominal)
- Transfer Rate: ≥ 100 gpm (nominal)

FILTRATE TRANSFER TO MCU

- Nominal Batch Size: 3800 gallons (nominal)
- Transfer Frequency: Once every 18 hours (nominal)
- Transfer Rate: 100 gpm (nominal)

MST/SLUDGE SOLIDS /FILTER CLEANING SOLUTION TRANSFER TO LPPP-PPT

- Nominal Batch Size: 2500 gallons (nominal)
- Transfer Frequency: Upon obtaining 5 wt. % solids in the LWPT (nominal).
- Transfer Rate: 100 gpm (nominal)
MST/SLUDGE SOLIDS TRANSFER TO PRFT

- Nominal Batch Size: 3000 gallons (nominal)
- Transfer Frequency: Upon obtaining 5 wt% solids in the LWPT (nominal)
- Transfer Rate: 100 gpm (nominal)

SE TRANSFER TO 221-S

- Nominal Batch Size: 700 gallons (nominal)
- Transfer Frequency: Once every 24 hours (nominal).
- Transfer Rate: 100 gpm (nominal)

6.1.2.3 Operating Concerns

Initial evaluations of chemical releases were performed for DWPF and showed there is no potential to exceed chemical evaluation guidelines (Ref. 30, 31). In addition, for 512-S it was determined the bounding event would not result in a source term that had the potential to exceed guidelines. This determination was based on an analysis of the waste material volumes necessary to achieve chemical safety significant evaluation guideline concentrations (Ref. 27). Chemical releases to the environment from 512-S, LPPP, or DWPF facilities are too low to be a concern during normal operation as explained below. The amount of ammonia released from the low point pump pit stack is permitted by the state, and meets OSHA standards. The principal concern in the operation of the interarea transfer system is the release of radioactive materials into the air and/or on the ground. Possible pathways include:

- A leak from a core transfer line subsequently leaks from the jacket into the surrounding soil
- A leak from a pump cell into the soil
- An abnormal discharge through the stack of the pump pit vent systems

Although an explosion in a transfer line/jacket or pump cell has been identified in the hazard analyses, the frequency and consequences were demonstrated to be sufficiently low such that this event is not considered as an operating concern.

TRANSFER LINE CONCERNS

The transfer lines included in the design (Sludge Slurry, Recycle Waste, MST/Sludge Solids, SE and Filtrate) are totally encased in carbon steel jackets. Transfer lines are well above the highest water table elevation ever recorded for the locale. The actual water table elevations for various conditions are described in Chapter 3. The interarea transfer lines are periodically leak checked to assure pressure boundary integrity.
LEAKS IN AND FROM A PUMP CELL

Each cell in the LPPP and the 512-S is lined with stainless steel and the floor of the cell is sloped to a sump equipped with level detection and alarm system. An underliner sump is also installed under each cell to collect leaks if a breach of the cell containment were to occur. Leaks to the LPPP underliner sumps are detected by a conductivity probe.

The probability of overflowing a pump tank is mitigated by the level detection system in each pump tank which shuts off the transfer pump if the high level alarm is not acted upon by the operator. There are no Safety Class items or TSRs required for this event (Subsection 9.4.2.8).

ABNORMAL RELEASE OF RADIOACTIVITY TO THE ATMOSPHERE

Process vessel vent systems are installed at the LPPP and 512-S to limit the release of radionuclides to the atmosphere during normal operation and in the event that primary containment is breached (tank overflow, leaks, or pressurization of the tank vapor space).

In these vent systems, vapor space purges of all pump tanks and the air purge of the cells are drawn through HEPA filters. The quantity of radioactive materials projected to be released to the atmosphere from the LPPP and 512-S annually during normal operations complies with the orders and standards listed in Section 7.1.1.

6.1.3 DELETED

6.1.4 ACTINIDE REMOVAL PROCESS

The feed stream of salt solution is pumped from a selected Tank Farm HLW storage tank, through an interarea transfer line to either the 241-96H Facility for MST strikes or directly to 512-S. The decision to strike individual 512-S feed batches with MST is determined by CST. The 241-96H and 512-S Facilities make up the ARP operations.

Operations performed in the LWPT include:

- Dilution of the ARP Feed
- Chemical treatment (sorption)
- Solids concentration
- Solids washing
- Filter Cleaning

6.1.4.1 Dilution of 512-S Feed

The 512-S Feed coming to the LWPT may have a high sodium concentration and may require dilution. In such cases the 512-S Feed is diluted with caustic and/or process water to obtain the desired sodium concentration.
6.1.4.2 Chemical Treatment (Sorption)

MST can be added to the ARP Feed in H-Area, however MST may be added in LWPT if required. The MST solid particles are contacted with the ARP Feed to adsorb Sr-90 and Actinide radioactive nuclides.

6.1.4.3 Solids Concentration

The MST/Salt Solution is sent to the LWPT in 512-S. In the LWPT the solids are removed by pumping the slurry through the crossflow filter. The concentrated solids exit the filter tubes and return to the LWPT. Filtrate is routed from the shell side of the crossflow filter to the LWHT. Filtration continues until the desired solids concentration is reached. Several batches of salt solution are processed until the concentration of solids in the process heel is high enough to be transferred to DWPF. The contents of the LWHT are transferred to MCU. The 512-S process is illustrated in Figure 6.1-1.

6.1.4.4 Solids Washing

Once the desired solids concentration has been reached, a large amount of sodium may reside within the remaining heel. If so, the heel is washed with water, to lower the sodium concentration, before it can be sent to DWPF for vitrification. The heel and additional wash water are filtered similarly to the concentration step. The spent wash water is sent to the LWHT, and the solids are collected in the LWPT. After washing, the heel is then transferred to the LPPP-PPT.

6.1.4.5 Filter Cleaning

During filtration, the filter may become clogged with solids. To remove these solids, solution is backpulsed through the filter tubes. A backpulse operation is performed when the filtrate flow falls below an acceptable level. Filtrate can be used as the backpulsing solution if the Cs-137 concentration in the filtrate is less than 1.1 Curies/gallon, otherwise water is used.

If filtrate flow is not sufficiently restored by backpulsing, the filter will be chemically cleaned after washing the solids in the LWPT. The spent cleaning chemicals are directed to the LWPT. From there, they are transferred to the LPPP-PPT. The cleaning chemicals also serve as a line flush for the underground header between 512-S and the LPPP. This addition of cleaning chemicals to the heel in the LPPP-PPT lowers the solids concentration in the LPPP-PPT.
6.1.5 MELTER FEED PREPARATION

Melter feed preparation facilities in the Chemical Process Cell (CPC) receive, treat and adjust waste slurries and solutions to prepare feed for the glass melter. Although CPC operations are done with batches of various materials, the melter is designed to be operated continuously. Major vessels and corresponding operations used to prepare melter feed are listed below. Flowsheets for the process are found in Figures 6.1-4 and 6.1-5.

6.1.5.1 Sludge Receipt and Adjustment Tank

The Sludge Receipt and Adjustment Tank is used for initial sludge treatment operations. The SRAT operations typically include the following:

- Sludge receipt
- MST/Sludge Solids receipt from the PRFT
- Sampling
- Formic Acid and Nitric Acid addition
- Concentration
- SE receipt from the SEFT
- Mercury stripping and recovery
- Sampling of product
- Transfer to SME.

SLUDGE AND MST/SLUDGE SOLIDS RECEIPT AND SAMPLING

Using the interarea transfer facilities, washed sludge slurry is pumped from H-Area to the LPPP and then pumped to the SRAT, MST/Sludge Solids are pumped from LWPT in 512-S to the LPPP and then to the PRFT and SE is transferred via two jumpers in the LPPP to the SEFT. After a sludge transfer is completed, sludge contents may be boiled off to make room for the MST/Sludge Solids and later the SE. A SRAT receipt sample would be taken after the MST/Sludge Solids are added. Results from the analyses of this SRAT sample are used to determine the appropriate quantity of nitric acid and formic acid to be added to the sludge slurry in the SRAT. Once the acid has been added, the SRAT is boiled up to remove mercury, held at a boiling temperature and SE is added. MST/Sludge Solids and SE may not be added in each SRAT batch. If the MST/Sludge Solids were not added, then the SRAT receipt sample would be pulled after the sludge is received and tank is agitated.

NITRIC ACID AND FORMIC ACID ADDITION AND REACTION

After samples have been analyzed, the contents of the SRAT are heated and the required quantities of nitric acid and formic acid are added at a controlled rate to the SRAT. If necessary, the slurry is then concentrated by evaporating water.
MERCURY RECOVERY

After chemical additions are complete, boilup can be continued at the desired steam flow until sufficient time has elapsed to remove mercury from the slurry by steam distillation. Steam-stripped mercury from the SRAT is condensed in the SRAT condenser and accumulates in the Mercury Water Wash Tank (MWWT). The mercury is transferred to the Mercury Purification Facility for additional treatment and purification.

6.1.5.2 Slurry Mix Evaporator

The Slurry Mix Evaporator (SME) operation is used to prepare a feed batch suitable for feeding the glass melter. In the SME, glass frit is added to the slurry product from the SRAT. The resultant feed batch is then concentrated, as needed. The SME operation uses the following general batch sequence:

- Adjusted sludge slurry receipt from the SRAT
- Spent frit addition
- Fresh frit addition
- Concentration
- Cooling and sampling
- Formic, , and/or nitric acid addition for redox and/or pH adjustment, if required
- Transfer to MFT

ADJUSTED SLUDGE SLURRY FROM THE SRAT

After sludge slurry is adjusted in the SRAT, it can be transferred from the SRAT to the SME if space is available in the SME.

Process knowledge or results from a sample are used to calculate both the total frit that must be added to the SME and the endpoint volume for the SME concentration step. Total solids in the SME are calculated using process knowledge or the analysis of the slurry received in the transfer, and the previous SME analysis for the initial SME heel. If required, additions such as partial SRAT transfers or chemical additions may be performed.

SPENT FRIT ADDITION

Spent frit slurry from canister decontamination operations is transferred to the SME via the CDC-SME isolation pot. Spent frit slurry is a waste stream generated when the surface of filled glass canisters are decontaminated by frit blasting. Multiple transfers from the CDC may be made for a single SME batch if space in the SME is available. Concentration may be performed during and between additions of spent frit slurry or a slurry of fresh frit (see below).
FRESH FRIT ADDITION

The difference between the total frit required and the frit received from spent frit slurry is added as a slurry of fresh frit from the Process Frit Slurry Feed Tank (PFSFT). Fresh frit is transferred as a slurry in dilute formic acid. If required, fresh frit addition can be made in multiple transfers, and a concentration step can be done during and between transfers to provide adequate space in the SME to accommodate the addition.

FORMIC OR NITRIC ACID ADDITION (OPTIONAL)

Either formic acid or nitric acid may be added to the SME as necessary to control oxidation/reduction reactions in the melter or to adjust the pH to improve rheology of the slurry. If acid adjustment of the melter feed is required, the SME contents are first heated and then the required volume of acid is transferred. The temperature of the SME contents is maintained during the addition. Nitric acid may also be supplied to the MFT for Melter feed adjustments.

CONCENTRATION

During heating for the concentration step, steam flow is normally reduced as the temperature nears boiling to reduce the likelihood of an eructation. After boiling begins, the steam flow is increased to the desired boilup rate. Condensate from the SME condenser flows by gravity to the SME. Concentration continues until the calculated evaporation endpoint is reached. Small amounts of residual mercury not removed from the sludge slurry in the SRAT may steam-distill with the overheads and collect in the SME. If required, additional frit is added, and the concentration step is repeated. If additional frit is not required, operation proceeds to the cool down step.

The SME evaporation endpoint is the total solids and insoluble solids concentration range that meet rheological constraints for pumping of the slurry. Before transfer to the melter, the melter feed batch contents are analyzed (typically in the SME) to ensure that the melter feed contents in the batch are within the TSR limits (Reference 18).

6.1.5.3 Off-Gases from CPC Processes

Off-gases from CPC processes are predominantly carbon dioxide and oxides of nitrogen. Significantly lower levels of hydrogen, ammonia, and ADPs are also generated in CPC operations. These gases typically evolve during SRAT operations.

Carbon dioxide is evolved first from the reaction between carbonates in the slurry and the acid that is added in the SRAT. Oxides of nitrogen are then generated in the SRAT as the nitrite decomposes. When the formic acid is added to the SRAT, a small portion of the formic acid is decomposed to hydrogen and carbon dioxide. Significant hydrogen generation does not begin until essentially all the nitrite has decomposed. Purge air/nitrogen from the Primary Purge System is used to dilute flammable gases in CPC vessels to mitigate flammability hazards at the maximum rate of production. The Primary Purge System is supplemented by
the CPC Safety Grade Nitrogen Purge systems, which is actuated automatically if the primary purge pressure decreases below a pre-set value.

Ammonium ion is produced during the SRAT cycle through a reaction between formic acid and nitrate. Both the decomposition of formic acid and the reaction between formic acid and nitrate to produce ammonium ion are catalyzed by the presence of noble metals that are components in the sludge.

Ammonia is evolved in the SRAT, in the Slurry Mix Evaporator (SME) and in the Melter Feed Tank (MFT), principally because the pH of the slurry continues to increase gradually after the initial acid treatment in the SRAT. Installed ammonia scrubbers are designed to reduce the ammonia concentration in the process vessel ventilation system and accordingly mitigate the formation and accumulation of ammonium salts such as ammonium nitrate. Separate scrubbers are located downstream of the SRAT and SME condensers. A third scrubber, located on the RCT, may be utilized to treat the combined vessel vents from the MFT and the RCT. SRAT and SME condensate, accumulated in the SMECT, is maintained at the proper pH using nitric acid and serves as the source of scrub solution to the ammonia scrubbers (except for the SME scrubber where scrub solution is no longer supplied). This condensate is periodically transferred to the RCT, treated with corrosion inhibitors and sent to the H-Area Tank Farm.

Antifoam is routinely added to the SRAT and SME to minimize foaming and mitigate sludge carryover events. After addition, antifoam decomposes into flammable ADPs, including HMDSO, TMS, and propanal. These ADPs may be present in the SRAT and SME from direct antifoam additions and in the MFT from SME slurry transfers. Additionally, ADPs are expected to be present in the condensate vessels (SMECT, RCT, RPT) as a result of carryover events or from ADPs condensing to the SMECT. These condensed ADPs would subsequently be transferred from the SMECT to downstream condensate vessels. Other degradation products may be present in very small quantities, or as transitional by-products of antifoam additions.

6.1.6 PROCESS VESSEL VENTILATION (PVV)

The Process Vessel Ventilation (PVV) system collects, decontaminates, and discharges the gases from in-cell process vessels to the Zone 1 exhaust system. The PVV serves all in-cell process vessels, except the melter which has its own off-gas treatment system. A simplified diagram of the system is shown in Figure 6.1-10.

Before they enter the PVV, all CPC vessel vent gases, except for off-gases from the decontamination waste transfer tank (DWTT) and Gas Chromatograph (GC) sample return lines (during use of the common return line downstream of the Formic Acid Vent Condenser FAVC), are cooled in the Formic Acid Vent Condenser (FAVC) to reduce water content in the gas stream and limit mercury emissions. A High Efficiency Mist Eliminator (HEME) in the FAVC mitigates entrained particulate and aerosols to reduce their concentration in the vapor entering the Process Vessel Vent Header (PVVH). The DWTT vents through a reflux condenser that is connected directly to the PVVH.

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Canister decontamination chambers and multiple PVVH hookup points in the Glass Melt Cell (MC), Remote Equipment Decontamination Cell (REDC), and Contact Decontamination and Maintenance Cell (CDMC) are connected directly to the PVVH. To collect vent gases from all vessels connected to the PVVH, sufficient pressure differential must be maintained in the header. The system includes an exhaust blower, installed spare exhaust blower, and controls to maintain the gas flow and pressure differential at the required levels. The controls are provided to start the spare blower. These blowers pull air through the Process Vessel Vent Filter (PVVF), which removes entrained particulates. The blowers are supplied with standby power in the event normal power is lost.

Condensation in the PVVF is prevented by passing the gas stream through a heater upstream of the filter. The exhaust from the PVVF undergoes further decontamination in the sand filter before release through the building exhaust stack. The Zone 1 exhaust system beyond the PVVF, including the sand filter, is described in Chapter 7.

6.1.7 MELTER OPERATION

6.1.7.1 Vitrification

Slurry from the Melter Feed Tank is fed to a joule-heated (resistance-heated) melter. Electrodes in the melt pool and dome heaters that traverse the melter plenum above the melt surface provide the energy required to dry and vitrify the solids. The slurry feed, which is introduced onto the top of the glass, forms a cold cap on the surface of the glass. The water is evaporated and drawn into the melter off-gas system. The cold cap in contact with the molten glass melts from the bottom and becomes part of the molten borosilicate waste glass. Vitrification and the melter off-gas treatment processes are depicted in Figure 6.1-6.

6.1.7.2 Canister Filling

Empty canisters are transferred into the melt cell from the canister storage area through a transfer tunnel. Canisters are placed on the Pour Turntable (PTT). After a throat protector is placed in the nozzle of the canister, a canister is moved under the melter pour spout for filling by rotating the PTT. A positioning arm is secured in place around the canister neck, which aligns the canister and prevents it from tilting. The stainless steel canister is connected to the pour spout by an air-operated bellows.

Pouring of the glass is started and stopped by controlling the differential pressure between the pour spout/canister and the pressure in the melter plenum. Pouring is stopped by increasing the pressure in the pour spout/canister relative to the melter plenum pressure. The bellows is raised after off-gasing, and the canister is rotated from beneath the pour spout with the Pour Turntable. As the Pour Turntable is rotated, an empty canister is positioned under the pour spout, secured in position, coupled to the pour spout bellows, and glass pouring is resumed. If the canister nozzle is not hot enough to insert a temporary inner canister closure plug, then the filled canister is moved to the Inner Canister Closure Station. A temporary inner canister closure plug is inserted after heating the canister neck. Refer to Subsection 5.2.3.3 for equipment details.
Monitoring of the canister level is necessary to avoid overfilling a canister. Canister glass level is tracked during pouring using an infrared camera, and canister weight is normally monitored with a load cell. However, the load cell is not required for normal melter operation (feeding/pouring).

6.1.7.3 Glass Sampling

When a glass sample is desired for analysis, a throat protector with an extendible sample cup is inserted into a canister on the PTT. When the canister containing the sample cup rotates under the pour spout of the melter for filling, a manipulator is used to push the sample cup under the molten glass stream and retract the cup after it has been filled. Any molten glass that overflows the sample cup simply goes into the canister.

6.1.7.4 Melter Draining

The melter contains a heated drain valve that may be used to empty the melter when the need arises. A canister turntable, located beneath the melter, may contain up to five standard stainless steel canisters. Each of the canisters can be positioned beneath the drain valve and coupled to the valve by way of a bellows. After the drain line is heated by the drain heaters to permit glass flow, an air-operated probe is raised from the bottom drain in the melter. Glass flow is stopped by retracting the probe. An air-operated plug valve is also provided as a backup device to stop the glass flow in the event the probe mechanism fails to seal.

6.1.7.5 Combustion

The oxidation state of glass is maintained in the melt pool and the cold cap to inhibit foaming in the melter, to prevent any significant release of ruthenium (as volatile RuO4) and to prevent reduction and accumulation of metals in the melter. Minor amounts of organic compounds (formate salts and hydrocarbons) are present in melter feed.

Air enters the melter through the primary film cooler and the backup off-gas film cooler (Subsection 5.2.3.4). If air flow to the film coolers falls below the minimum values, the feed to the melter is automatically shut off by a low flow interlock (Subsection 11.5.5).

6.1.7.6 Off-Gas Treatment

The melter off-gas flow consists principally of steam and non-condensable gases containing entrained particulate (including small particles of waste glass) and feed components that are volatile at the operating temperature of the melter (for example, mercury). The off-gas design assumes entrainment of 1 wt % of the non-volatile particles in the off-gas. The off-gas treatment is designed to maintain total atmospheric releases of radionuclides as low as reasonably achievable (ALARA).

The off-gas treatment process consists of two parallel systems. The off-gases are normally processed through the primary system and may be switched to the backup off-gas system if desired or whenever the primary system is unavailable. Automatic switch over from the
primary to backup off-gas system also occurs when process conditions warrant. Standby power is provided to both systems.

Semi-volatiles such as chlorides, feed entrainment, and glass splatter tend to coat the melter off-gas line and could eventually plug the line. To prevent this, a film cooler is used at the entrance of the off-gas line. Steam (as necessary) and/or air is injected through slots, providing a gas film over the wall in this critical area and cooling any glass splatter to a non-sticking solid. A wire brush may be remotely operated to mechanically clean the first few feet of line, if necessary. The off-gas line carries off-gas from the melter to the quencher for cooling, for condensing steam, and for partial removal of particulate matter. Cooled off-gas is discharged into the Off-Gas Condensate Tank (OGCT). Cooling coils are installed in the tank to control the temperature of condensate.

Off-gas from the OGCT next enters a two-stage Steam-Atomized Scrubber (SAS) system. The SAS system removes entrained particulate from the off-gas and returns them to the OGCT. The off-gas from the SAS is then passed through a condenser to further cool the gas and remove condensable components in the gas stream. A demister pad at the condenser exit removes residual liquid entrainment from the gas. The liquid collected in the condenser drains to the OGCT. Cooled off-gas then enters a High Efficiency Mist Eliminator (HEME), where fine particulate and droplets of liquid are removed. Any liquid collected in the HEME also drains to the OGCT.

Gas from the HEME passes through a heater and a High Efficiency Particulate Air (HEPA) filter assembly to remove any particulates that were not removed by other systems. The off-gas is heated above its dew point to prevent condensation from forming on the downstream HEPA filters. The gas is passed through HEPA filters in series before it is discharged into the Zone 1 ventilation exhaust tunnel by the off-gas exhauster. Final filtration is done in the sand filter before release through the building stack. The Zone 1 exhaust system beyond the exhaust tunnel is described in Chapter 7.

6.1.7.7 Pressure Control

Melter pressure control is important for two reasons: (1) to prevent uncontrolled releases to the process area; and (2) to control glass pouring. The entire off-gas system and the melter are maintained at a pressure lower than the process cell pressure to minimize vapors leaking into the process cell. Vapors are pulled from the melter into the OGCT. Suction on the melter and melter off-gas systems results from the operation of the quencher (located between the melter and the OGCT) and the exhauster located at the outlet of the off-gas system.

The pressure in the melter is controlled by introducing control air into the system between the film cooler and the quencher. The flow rate of the control air is regulated by varying the speed of the exhauster. The control air flow is used to offset occasional surges of off-gases that may be released in the melter during normal operation. As the melter pressure increases due to surges, the flow rate of the control air is decreased to regulate melter pressure to the desired value. The exhauster speed then increases to adjust control air flow back to the desired setpoint.
If the pressure in the melter vapor space is high, the Backup Off-Gas System is automatically switched into service. Feed to the melter is automatically stopped when the Backup Off-Gas System is activated. Feeding cannot be restarted until switchback to the primary system is completed.

A seal pot helps prevent the pressure in the melter from getting too high and initiating pouring of glass inadvertently. The seal pot is designed to quench steam from the melter and a baffle in the seal pot assures good vapor/liquid contact before vapor is vented to the cell.

The off-gas system is protected against large negative pressures by a vacuum relief valve located between the Off-Gas Condensate Tank and the Steam Atomized Scrubber. This will provide an air source for the off-gas exhauster to prevent a large vacuum. The valve will provide adequate flow for the exhauster running at maximum speed while maintaining a system pressure above the point at which the water from the seal pot is lifted into the melter.

6.1.8 CANISTER CLEANING, WELDING AND TRANSFER

After filling, the canister must be cleaned prior to transfer to the Glass Waste Storage Buildings. A temporary plug is installed at either the Pour Turntable or the Inner Canister Closure Station (ICCS). The temporary seal is then tested for leakage by the ICCS helium leak detector. If the seal does not meet the leak test requirements, a repair plug is inserted using the ICCS heater, and retested before decontamination of the canister outer surface. Refer to Subsection 5.2.3.3 for equipment details.

Filled canisters are transferred from the Melt Cell to the Canister Decontamination Cell for decontamination (See Figure 6.1-8). When the canister outer surface has cooled sufficiently, the potentially contaminated canister is decontaminated by blasting the entire exterior canister surface with an aqueous slurry of frit. After the canister has dried, the decontaminated canister is surveyed for transferable contamination by smearing the external surfaces. If the transferable contamination is less than established limits, the canister is transferred to the Weld Test Cell. Spent frit slurry from the canister decontamination cycle is sent to the SME to be used as part of the glass frit required in the melter feed preparation process (see Subsection 6.1.5.2).

After the canister surface is decontaminated, the canister is transferred to the Weld Test Cell (WTC) for final closure. To seal the canister, the temporary inner canister closure plug is pressed into the canister and a plug is welded into the throat of the canister using an upset-resistance welder. Weld quality is assured by control and measurement of welding parameters. Finally, the canister is surveyed for transferable contamination before it is transported to one of the Glass Waste Storage Buildings (GWSBs) for interim storage. Alternatively, canisters may be temporarily stored in a GWSB without final closure welds and returned to the Weld Test Cell for final closure (see Figure 6.1-8). The Shielded Canister Transporter (SCT) is used to transfer canisters to the GWSBs. For a description of the SCT, refer to Subsection 5.3.2.4.
6.1.9 MERCURY RECOVERY

Mercury recovered from the melter feed preparation is collected in the Mercury Water Wash Tank (MWWT), washed with water, and then transferred to the Mercury Purification Facility. The principal source of mercury is from steam stripping operations in the SRAT. Mercury from SRAT operations accumulates directly in the MWWT. Another source is mercury that may be steam stripped during the SME cycle and accumulated in the SMECT, since the SME condensate bypasses the MWWT. Mercury that accumulates in the SMECT is pumped to the MWWT.

Amalgams of mercury and noble metals which may accumulate in SRAT or SMECT mercury sumps over a long period of time (three to five years) can be pumped to the MWWT (Refer to Chapter 5 for pump description). The SMECT is an intermediate destination of mercury which has accumulated in, and been pumped from, other CPC/SPC tanks that have a mercury sump, including the PRFT, SEFT, SME, MFT, OGCT, RCT in the SPC, CPC, and the BUOGCT in the Backup Off-Gas Cell. All of the latter sources reach the SMECT through the mercury transfer header.

The mercury purification process equipment is located in the shielded Mercury Purification Facility (Ref: Subsection 5.2.3.5). Initial purification consists of a series of three washing operations: (1) a nitric acid batch wash in the MAWT; (2) a counter current wash using nitric acid in a packed column; and (3) a counter current wash using water in a packed column. Mercury may then be transferred from the shielded cells into a hood where further purification by vacuum distillation may be performed if desired. A radiation survey is made of the mercury before it is transferred from the shielded facilities to ensure it has been decontaminated sufficiently and will not be a radiation exposure hazard to personnel. Refer to Subsection 5.2.3.5 for a more complete description of the equipment. The flow sheet for the process is shown in Figure 6.1-7.

6.1.10 WASTE COLLECTION AND RECYCLE

Radioactive liquid wastes generated in DWPF are collected, inhibited, and transferred through the interarea transfer system to the H-Area tank farm. In DWPF, all aqueous waste streams containing radioactive contaminants are ultimately directed to the RCT for final adjustment before transfer through the LPPP to the H-Area tank farm. A system of floor drains, trenches, sumps, tanks, and transfer headers are used to collect various waste streams for ultimate transfer to and treatment in the RCT. Figure 6.1-9 illustrates this waste collection and treatment. Various components of this system are described below.

6.1.10.1 Recycle Collection Tank (RCT)

The RCT is located in the CPC and provides the capability to collect, treat, and transfer waste solutions, which result from CPC operations, melter off-gas operations, decontamination operations, and collection of miscellaneous fluids in sumps. Inhibitors are then added in the RCT and pH adjustments are made, if required, before the waste is sent to the H-Area tank farm. The RCT has two operational modes: receiving and processing. In the receiving mode,
the RCT accepts batch transfers of aqueous waste from various operations within 221-S. After sufficient waste has been transferred to constitute an RCT batch, RCT operations are switched to the processing mode during which no waste transfers into the RCT can be made. Corrosion inhibitors are added to the RCT to meet waste acceptance criteria for waste transferred to the H-Area Tank Farm, and the contents of the RCT are transferred to the LPPP-RPT by the DWPF Control Room Operator. Transfers to the H-Area Tank Farm are coordinated with the H-Area Control Room Operators. After the transfer is completed, RCT operation is returned to the receiving mode.

The vapor vent from the RCT is combined with the vapor vent from the Melter Feed Tank and drawn through an ammonia scrubber, which is not required to be scrubbing for operations. The vapor exiting the ammonia scrubber enters the process vessel ventilation system. When the scrubber is being utilized for ammonia reduction, acidic solution used in the scrubber is supplied from and returned to the SMECT.

6.1.10.2 Decontamination Waste Treatment Tank

The DWTT is located in the Chemical Process Cell. The DWTT collects spent solutions from equipment decontamination and miscellaneous sumps containing nitric acid. Use of oxalic acid is restricted as described in Chapter 8. This tank is used for these functions:

- Neutralize solutions with caustic (NaOH), if required.
- Digest (dissolve) the filter media of HEME and HEPA filters removed from service in a sodium hydroxide solution by simmering at or near boiling (This operation is done infrequently, since filters are replaced only when their performance degrades). Refer to Subsection 7.2.4.2 for details of this process.

DWTT waste batches are transferred to the RCT.

6.1.10.3 Formic Acid Waste Header (FAWH)

- The Formic Acid Waste Header (FAWH) is used to transfer solutions which are compatible with formic acid to the RCT. The sumps that discharge to the FAWH are listed below:
  - Melt Cell (MC) sump
  - CPC sumps (3)
  - Inlet tunnel collection sump (collection point for the following sumps and floor drains)
    - Sump in the air inlet to the sand filter
    - Floor drains in the north and west exhaust tunnels
    - Sump in the air outlet from the sand filter
    - Drain in the stack duct
Floor drain in the fan house inlet tunnel

Two of three floor drains located in the third level bus bar corridor discharge to a trench in the CPC which leads to a CPC Sump. The other floor drain discharges to the Hot Decontamination Waste Header (HDWH), See 6.1.10.5.

The drain in the stack duct is equipped with an automatic valve and a liquid detection device. This automatic valve is normally kept closed because the pressure difference between the floor drain and the inlet tunnel collection sump would allow air to leak into the inlet tunnel. When the detection device indicates a high liquid level in the drain, the valve opens to drain accumulated liquid from the stack duct.

6.1.10.4 Deleted

6.1.10.5 Decontamination Waste Headers

The Hot Decontamination Waste Header (HDWH) is used to transfer solutions which are compatible with nitric acid to the DWTT. One of three floor drains located in the third level bus bar corridor discharges to one of two sumps in the Crane Maintenance Area (CMA). Both sumps in the CMA discharge to the HDWH.

The Warm Decontamination Waste Header (WDWH) is used to transfer less radioactive (essentially no radioactivity) solutions that are compatible with nitric acid to the DWTT. The sumps and tanks that discharge to the WDWH are listed below.

- Sump in railroad well
- Sump in railroad tunnel airlock
- Glove box catch tank in the Manipulator decontamination room
  - Disassembly glove box drain
  - Decontamination glove box drain
  - Sump in decontamination room of the manipulator repair shop

- Sump in empty canister entry tunnel
- Sump in the Weld Test Cell (WTC)
- Sump in the Canister Decontamination Cell-WTC transfer tunnel
- Sump in the WTC-Canister Exit Tunnel
- Acid drain catch tank and sump
6.2 PROCESS FLOW DIAGRAMS, MATERIAL/CURIE BALANCES, AND PROCESS ENERGY

6.2.1 PROCESS FLOW DIAGRAMS

Figures 6.1-1 through 6.1-11 show the process flow paths for each major processing operation in DWPF. The principal process streams and key chemical additions are shown on Figures 6.1-1 and 6.1-11, and the accompanying data sheets.

6.2.2 CHEMICAL AND RADIONUCLIDE DESIGN BASES

6.2.2.1 DWPF Chemical Design Basis

Table 6.1-2 lists the nominal chemical composition of the insoluble and soluble solids in the washed sludge slurry and Table 6.1-6 lists the bounding chemical composition in the MST/Sludge Solids, Filtrate and SE that were used as the basis for the hazards and safety analyses of the DWPF vitrification process. Section 9.4.1.2 outlines the analytical process by which the chemical source terms and their consequences in the described accidents were analyzed.

The chemical composition of the design basis feed for 512-S is documented in Reference 27.

6.2.2.2 DWPF Radiological Design Basis

Tables 5.5-1, 5.5-2, 5.5-3, and 5.5-4 in Chap. 5 list the radionuclide contents of the feed streams and selected process streams that were used as the basis for shielding design for the vitrification process. Table 9.4-2 lists the curie balance for the feed streams and selected process streams used in the DWPF safety calculations and for the feed acceptance criteria for radioactive waste feed, found in the TSRs (Reference 18).

The curie balance that was used as the basis for DWPF shielding design, listing the radionuclide concentration in every process stream shown on the design basis process flow diagrams, is available in Appendix J of Reference 7.

6.2.3 MATERIAL BALANCES

Several process and equipment changes have been implemented in DWPF since the design basis material balance was produced.

- The Actinide Removal Process (ARP) may use Monosodium Titanate to adsorb actinides and strontium in the Salt Solution. The Filtrate is transferred from the LWHT to MCU. The MST/Sludge Solids, Filtrate and SE from MCU is sent to DWPF for vitrification. SE from MCU is sent to DWPF for vitrification.

- Ammonia scrubbers have been installed in the CPC and may be utilized to mitigate accumulation of ammonium nitrate in the process vessel ventilation system. Studies have shown that ammonia is produced during the SRAT cycle which could
subsequently evolve from the SRAT, SME, MFT, and RCT into the process vessel ventilation system and, reacting with HNO₃ vapor, deposit ammonium nitrate in the vent system. This would require frequent shutdowns to clean out the vents and remove the material.

- Controlled air or nitrogen purges to the SRAT, SME, SMECT, MFT, RCT, DWTT, SEFT, and PRFT are used to prevent the production of a flammable gas mixture in the CPC and SPC vessel spaces and vent system due to the production of hydrogen from radiolysis/thermolysis of process stream constituents and catalytic decomposition of excess formic acid during the melter feed preparation processes.

- A Safety Grade Nitrogen purge system has been provided as backup to the Primary Purge system in the CPC and SPC. This will be actuated automatically if the Primary Purge system pressure drops. The CPC safety grade nitrogen purge system is Safety Class (see Section 4.3 for details).

- Duplicate gas chromatography instruments are installed on the SRAT and SME vent lines to monitor hydrogen concentrations in the vapor effluents.

- Nitric acid has replaced formic acid to acidify the sludge sent to the SRAT in order to maintain the proper formate-to-nitrate balance to control melter oxidation-reduction chemistry.

6.2.4 PROCESS ENERGY

Temperatures, pressures, and enthalpies of process streams are included in the material balance tables. General energy considerations for the process include:

- The DWPF process requires large energy inputs. Major inputs are required for waste pumping, agitation, heating, evaporation, melting, canister decontamination, and welding. The only significant exothermic reaction is combustion of residual organic in the melter but this heat of combustion is small compared with the heating demand, which is supplied electrically.

- Cooling coils are provided in certain process tanks to expedite cooling following treatment or evaporation and before sampling or transfer. Cooling is not required to remove heat of reaction or radioactive decay.

- Cooling coils are provided on the outside shell of the melter to cool the surface temperature of the melter shell to minimize thermal updrafts that could spread contamination when cell covers are removed.

- Radioactive decay heat is not a significant process factor compared with steam and electrical inputs. It is negligible with regard to cell ventilation, process heating and cooling, and cooling of the glass canister surface prior to wet decontamination. Decay heat is only significant with regard to canister storage in concrete wells of the Glass Waste Storage Buildings (GWSBs) where, if the glass gets too hot, it can reduce the strength of the surrounding concrete.
6.3 OPERATING CONSIDERATIONS

6.3.1 CRITICALITY

Criticality analyses have been performed for radioactive operations at DWPF with washed sludge, 512-S Feed, MST/Sludge Solids and SE. These are summarized in FSAR Chapter 8, Section 8.5.

6.3.2 CHEMICAL SAFETY (SEE SAFETY ANALYSIS IN SECTIONS 9.3 AND 9.4)

Several of the chemicals used or produced in the DWPF process can present safety hazards to workers (burns, toxicity, flammability, reactivity, etc.) if they are not properly handled or controlled. These chemicals include: formic acid, nitric acid, sodium hydroxide, potassium nitrate, potassium permanganate, mercury, oxalic acid, Monosodium Titanate and sodium nitrite. Potential hazards related to chemicals used in the DWPF processes are summarized in Subsection 6.1.1.

6.3.3 EXPLOSIVES AND COMBUSTIBLES

If controls are not provided, explosive or flammable concentrations of combustibles could accumulate in several areas in DWPF including 512-S and the LPPP. The potential for flammable atmospheres is due to accumulation of hydrogen, carbon monoxide, and/or organic vapor in DWPF cells, vessels or other confined vapor space. Depending on the location and operating condition, hydrogen is generated by the following mechanisms: radiolysis of water (organics contribute if present), thermolytic decomposition of process stream constituents, and catalytic decomposition of formic acid. Organic vapors are produced from the volatilization of organics in aqueous solution (e.g., Isopar L carryover in Strip Effluent) or from degradation of antifoam (i.e., ADPs).

Methods utilized at DWPF to suppress the potential for combustion are: (1) dilution of a combustible gas mixture by purging with air/nitrogen below the LFL limit, (2) reducing the concentration of oxidant in the mixture by the addition of an inert gas, and (3) blanketing tanks to prevent the intrusion of air. The purging (dilution) is the simplest and cheapest way to accomplish the necessary margin of safety, but it can lead to increased emissions of volatile organics if a significant quantity of organic liquid is present.

Since total quantities of volatile organics are low in the CPC, SPC and Melt Cell (limited by aqueous solubility), purging was chosen as the method of control in these process cells. Nitrogen (N\textsubscript{2}) is used for purging the vapor space in the RPT, SPT, and PPT in the LPPP and in the LWPT, LWHT, and Surge Tank in the 512-S.

Tanks containing concentrated formic acid at DWPF are blanketed. Nitrogen is used to keep these tanks at a slight positive pressure.
6.3.4 DELETED

6.3.5 SPILLS

The potential for spills of process solutions exists throughout DWPF facilities, including the LPPP and 512-S. For example, a spill may occur as the result of tank overflow, jumper leak, or missing jumper. The potential for tank overflow is mitigated during routine transfers by the level monitoring and alarms systems that are interlocked to stop the appropriate transfer system associated with each process vessel. Infrequently performed transfers are controlled per approved operating procedures that stop a transfer before an overflow potential has been reached or if a leak has been detected. A pressure-driven leak of slurry from slurry transfers could occur. Sump level monitors and alarms provide a system to detect if a spill or leak has occurred and sample lines permit analysis of contents.

The potential for an eructation in the evaporators used to prepare melter feed (SRAT, SME) is mitigated by controlling the rate of steam flow as boiling temperature is approached and by slurry temperature differential monitoring systems that are interlocked to the steam delivery system.

Loss of containment of the glass melt is a spill unique to the vitrification process, since the spilled material is at a greatly elevated temperature and the volatility of certain radionuclides will increase releases to the cell atmosphere. A stainless steel catch pan is provided beneath the canister turntables to contain glass spillage. With the pour spout open to atmosphere, sufficient pressure differential cannot be developed to initiate pouring. Melter feed may or may not be discontinued during canister changeout; however, melter level could increase such that upon loss of vacuum in the melter vapor space (due to off-gas system failure or an excessive surge in process gas/steam evolution), glass flow could occur without a canister in place. Controls described in Subsection 6.1.7 are designed to preclude it.
6.4 PROCESS CHEMISTRY

Major process chemistry and physical and chemical data that characterize the DWPF process are described in this section. All reactions go to completion unless otherwise noted by a percent completion in parentheses following the reaction. The equations and the material balance volumes and flows represent processing of a complete batch for the process being discussed as if it were a continuous process. Actual processing is carried out on a batch basis, except for the melter. DWPF is designed to process HLW sludge prepared in H-Area. This preparation is not part of the DWPF process covered by this FSAR (Refer to Section 1.1 and Figure 1.1-1, 1.1-4 and 1.1-5 for DWPF buildings and interfaces). A complete set of the chemical reactions used to prepare material balance tables is documented separately in DPST-89-271 (Reference 8). Process parameters for batching are documented in WSRC-TR-92-480 (Reference 6) for the SRAT and SME processing.

6.4.1 512-S

6.4.1.1 512-S Feed Stream

Monosodium Titanate may be added to the 512-S Feed in H-Area to adsorb soluble strontium and actinides. The stoichiometry listed below describes the chemistry that is believed to occur during the MST sorption process

\[
\begin{align*}
\text{Sr(OH)}_2 + 2\text{NaTi}_2\text{O}_5\text{H} & = 2\text{H}_2\text{O} + \text{Sr(\text{NaTi}_2\text{O}_5)}_2 \\
\text{UO}_2\text{(OH)}_2 + 2\text{NaTi}_2\text{O}_5\text{H} & = 2\text{H}_2\text{O} + \text{UO}_2(\text{NaTi}_2\text{O}_5)_2 \\
\text{PuO}_2 + 2\text{NaTi}_2\text{O}_5\text{H} & = \text{H}_2 + \text{PuO}_2(\text{NaTi}_2\text{O}_5)_2 \\
\text{SrO} + 2\text{NaTi}_2\text{O}_5\text{H} & = \text{H}_2 + \text{SrO(\text{NaTi}_2\text{O}_5)}_2 \\
\text{SrCO}_3 + 2\text{NaTi}_2\text{O}_5\text{H} & = \text{H}_2 + \text{CO}_2 + \text{SrO(\text{NaTi}_2\text{O}_5)}_2
\end{align*}
\]

6.4.2 DELETED

6.4.3 MELTER FEED PREPARATION

6.4.3.1 Acidification of Sludge Slurry

The sludge slurry must be treated with an acid to control rheology and with a reductant to reduce mercury and manganese. In order to provide the proper oxidation/reduction balance in the melter, a portion of the SRAT acid requirement is provided by nitric acid addition to the SRAT (nitrate is oxidizing to the glass melt). The remainder of the acid requirement and the reductant is provided by concentrated or dilute formic acid additions directly to the SRAT. Process off-gases from acid treatments in the SRAT include carbon dioxide, nitric oxide (which readily oxidizes to nitrogen dioxide), hydrogen and ammonia. The hydrogen is produced by the dehydrogenation of formic acid catalyzed by noble metals. Ammonium ions
are produced due to the reaction between formic acid and nitrate catalyzed by the noble metals present in the sludge. Ammonia is evolved primarily as a function of temperature, pH and boilup rate. During the SRAT cycle, the pH of the slurry gradually rises.

The following stoichiometry is used in the material balance model to describe the potential pathways for the production of hydrogen and ammonia.

**AMMONIA PRODUCTION**

\[
\begin{align*}
\text{NH}_4\text{COOH} & = \text{NH}_3 + \text{HCOOH} \\
2 \text{HCOOH} + \text{NaNO}_3 & = \text{NH}_3 + \text{NaOH} + 2 \text{CO}_2 + \text{O}_2 \\
\text{NaNO}_3 + 4 \text{H}_2 & = \text{NH}_3 + \text{NaOH} + 2 \text{H}_2\text{O}
\end{align*}
\]

**HYDROGEN PRODUCTION**

\[
\begin{align*}
\text{HCOOH} & = \text{H}_2 + \text{CO}_2 \\
\text{NaCOOH} + \text{H}_2\text{O} & = \text{NaOH} + \text{CO}_2 + \text{H}_2
\end{align*}
\]

The following reactions describe the reduction of metal oxides that occur during formic acid addition:

\[
\begin{align*}
\text{HgO} + \text{HCOOH} & = \text{Hg} + \text{CO}_2 + \text{H}_2\text{O} \\
\text{MnO}_2 + 3 \text{HCOOH} & = \text{Mn(COOH)}_2 + \text{CO}_2 + 2 \text{H}_2\text{O} & (40-60\%) \\
\text{RhO}_2 + 2 \text{HCOOH} & = \text{Rh} + 2 \text{CO}_2 + 2 \text{H}_2\text{O} & (99\%) \\
\text{PdO} + \text{HCOOH} & = \text{Pd} + \text{CO}_2 + \text{H}_2\text{O} & (99\%) \\
\text{Ag}_2\text{O} + \text{HCOOH} & = 2 \text{Ag} + \text{CO}_2 + \text{H}_2\text{O} & (99\%)
\end{align*}
\]

6.4.3.2 **Evaporation and Mercury Stripping**

Formic acid is added to the SRAT. During this addition, mercury oxides in the radioactive sludge are reduced to mercury, which is steam stripped, condensed, and accumulated in the Mercury Water Wash Tank.

6.4.3.3 **Frit Addition and Final Solids Adjustment**

In the SME, the required quantity of frit is added to the sludge slurry, and the final solids content is adjusted. The primary process off-gases from SME operations are hydrogen and ammonia. Hydrogen continues to be generated through the dehydrogenation of formic acid. Ammonia evolution is greater than in the SRAT due to an increasing pH. The increase in pH is due to the continued dehydrogenation of the formic acid and neutralization of the formic acid by the alkali content of the frit that is added. After frit adjustment and concentration in the SME are complete and the contents are determined to be acceptable, the slurry is transferred to the Melter Feed Tank (MFT).
6.4.3.4 Antifoam Degradation Products

Antifoam is routinely added to the SRAT and SME to minimize foaming and mitigate sludge carryover events. After addition, antifoam decomposes into flammable ADPs, including HMDSO, TMS, and propanal. These ADPs may be present in the SRAT and SME from direct antifoam additions and in the MFT from SME slurry transfers. Additionally, ADPs are expected to be present in the condensate vessels (SMECT, RCT, RPT) as a result of carryover events or from ADPs condensing to the SMECT. These condensed ADPs would subsequently be transferred from the SMECT to downstream condensate vessels. Other degradation products may be present in very small quantities, or as transitional by-products of antifoam additions.

6.4.4 VITRIFICATION

There are at least three reaction zones in the melter: (1) the cold cap, (2) the vapor space, and (3) the glass melt. The melter feed slurry is introduced from the MFT through a feed tube to the melter. The slurry drops onto the molten glass surface where the slurry dries, forming a semi-solid feed pile or “cold cap” which melts from the bottom, forming the borosilicate glass. As the cold cap heats, some of the metal salts decompose to metal oxides and gases.

In pilot-scale vitrification tests, about 1.0 wt% of the vitrification products were physically entrained into the vapor exiting the melter plenum. Similarly, waste glass particles are expected to be entrained during vitrification in DWPF. The stoichiometry listed below describes the chemistry that is believed to occur during the vitrification process. The reactions are based on pilot plant and modeling studies. The complete set of reactions used to prepare material balance tables is separately documented (Reference 8).

NITRATE DECOMPOSITION

\[ 4 \text{NaNO}_3 + 6 \text{NaCOOH} = 5 \text{Na}_2\text{O} + 4 \text{NO} + 6 \text{CO}_2 + 3 \text{H}_2\text{O} \]
\[ 4 \text{MNO}_3 = 2 \text{M}_2\text{O} + 2 \text{N}_2 + 5 \text{O}_2 \quad \text{where } \text{M} = \text{Na, Cs, K}. \]
\[ 2 \text{M(NO}_3)_2 = 2 \text{MO} \text{ (metal oxide)} + 2 \text{N}_2 + 5 \text{O}_2 \quad \text{where } \text{M} = \text{Mg, Ca, Sr, Ba}. \]

SULFATE DECOMPOSITION

\[ 2 \text{CaSO}_4 + 2 \text{NaCOOH} = 2 \text{CaO} + \text{Na}_2\text{O} + 2 \text{SO}_2 + 2 \text{CO}_2 + \text{H}_2\text{O} \quad \text{(20%)} \]
\[ 2 \text{Na}_2\text{SO}_4 + 2 \text{NaCOOH} = 3 \text{Na}_2\text{O} + 2 \text{CO}_2 + 2 \text{SO}_2 + \text{H}_2\text{O} \quad \text{(40%)} \]
\[ \text{PbSO}_4 = \text{PbS} + 2 \text{O}_2 \]
FORMATE DECOMPOSITION

Production of flammable gases (carbon monoxide and hydrogen) during vitrification primarily occur during the decomposition of formate salts in the melter feed:

\[
M(COOH)_2 = MO + CO + CO_2 + H_2 \quad \text{where } M = \text{Mn, Ni, Ca, Cu, Co, Zn, Mg, Sr}
\]

\[
2\ MCOOH = M_2O + CO + CO_2 + H_2 \quad \text{where } M = \text{Na, K, Cs}
\]

\[
3\ \text{UO}_2(COOH)_2 + O_2 = \text{U}_3\text{O}_8 + 3\ \text{H}_2\text{O} + 3\ \text{CO} + 3\ \text{CO}_2
\]

\[
2\ \text{Y(COOH)}_3 = \text{Y}_2\text{O}_3 + 3\ \text{CO} + 3\ \text{CO}_2 + 3\ \text{H}_2
\]

OXALATE DECOMPOSITION

Additional carbon monoxide can be produced from oxalate salts in the melter feed:

\[
\text{Na}_2\text{C}_2\text{O}_4 = \text{Na}_2\text{O} + \text{CO}_2 + \text{CO}
\]

\[
\text{CaC}_2\text{O}_4 = \text{CaO} + \text{CO}_2 + \text{CO}
\]

NOBLE METAL FORMATION

Noble metals that are not reduced by treatment in the CPC may be reduced in the melter:

\[
\text{RhO}_2 = \text{Rh} + \text{O}_2
\]

\[
2\ \text{PdO} = 2\ \text{Pd} + \text{O}_2
\]

\[
2\ \text{Ag}_2\text{O} = 4\ \text{Ag} + \text{O}_2
\]

\[
\text{RuO}_2 = \text{Ru} + \text{O}_2
\]

VOLATILIZATION

Aqueous waste that accumulates in the Melter Off-Gas Condensate Tank is comprised of the water vapor exiting the melter plenum (and subsequently condensed), steam added to the Steam Atomized Scrubbers (and subsequently condensed), steam from the film cooler (and subsequently condensed), condensate from the condenser, and water spray from the High Efficiency Mist Eliminator. The waste will also contain radioactive contaminants. The waste is transferred to the Recycle Collection Tank (RCT). The radioactivity in the waste is the result of physical entrainment of non-volatiles into the vapor exiting the melter plenum and of melter feed components that volatilize during vitrification and subsequently are condensed and routed to the Off-Gas Condensate Tank. The following stoichiometry for volatile radionuclides was used to design the off-gas system:

\[
\text{Cs}_2\text{O} = \text{Cs}_2\text{O} \ (\text{vol.}) \quad (10\%)
\]

\[
\text{RuO}_2 + \text{O}_2 = \text{RuO}_4 \ (\text{vol.}) \quad (1\%)
\]
Several non-radioactive components also volatilize during vitrification and are described by the following stoichiometry:

\[
\begin{align*}
\text{NaF} &= \text{NaF (vol.)} \quad (33\%) \\
\text{NaCl} &= \text{NaCl (vol.)} \quad (50\%) \\
\text{NaI} &= \text{NaI (vol.)} \\
2 \text{HgO} &= 2 \text{Hg} + \text{O}_2
\end{align*}
\]

**FLAMMABLE GASES PRODUCED DURING VITRIFICATION**

During the vitrification process the two main flammable gasses produced are hydrogen and carbon monoxide. Flammable gas concentration in the melter off-gas are maintained less than or equal to 60% CLFL during normal operations and 95% CLFL during a design-basis melter off-gas surge event (Ref. 18).

6.4.5 MELTER OFF-GAS TREATMENT

Vapor exiting the melter is diluted with air and steam (if required) in the Off-Gas Film Cooler (OGFC) to reduce the vapor temperature before it enters the quencher. The temperature of the vapor is further cooled below its dew point in the quencher to condense the majority of the water vapor. Residual vapors are drawn through a series of abatement systems to remove particulate radioactivity (primarily Cs\textsuperscript{137}) and mercury before they are discharged to the air tunnel that leads to the sand filter.

6.4.6 NEUTRALIZATION OF SPENT DECONTAMINATION WASTE

Solutions from equipment decontamination (nitric acid and/or potassium permanganate) and the contents of sumps that potentially can accumulate nitric acid may require treatment before they are recycled to H-Area. Normally, these solutions will only be neutralized in the Decontamination Waste Treatment Tank (DWTT) if required before they are transferred to the Recycle Collection Tank (RCT). Inhibitor and pH adjustments will be made in the RCT to meet the Waste Compliance Plan, (Reference 21). The chemistry describing the process in the DWTT is shown in the following reactions:

\[
\begin{align*}
\text{HNO}_3 + \text{NaOH} &= \text{NaNO}_3 + \text{H}_2\text{O} \\
\text{Hg(NO}_3\text{)}_2 + 2 \text{NaOH} &= \text{HgO} + 2 \text{NaNO}_3 + \text{H}_2\text{O}
\end{align*}
\]
6.4.7 RECYCLE WASTE TREATMENT

Condensate from CPC dewatering operations, condensate from the melter off-gas condensate tank and backup off-gas condensate tank, and neutralized spent decontamination wastes are transferred to the Recycle Collection Tank (RCT) for inhibitor adjustment to meet the Waste Compliance Plan (Ref. 21) before the waste is sent to H-Area. The primary reactions are described by the following stoichiometry:

\[
\begin{align*}
\text{HNO}_3 + \text{NaOH} & = \text{NaNO}_3 + \text{H}_2\text{O} \\
\text{HCOOH} + \text{NaOH} & = \text{NaCOOH} + \text{H}_2\text{O}
\end{align*}
\]

The condensate from the SMECT is used as the scrub fluid for the ammonia scrubbers (except for the SME scrubber where scrub solution is no longer supplied) in the Chemical Process Cell when the scrubbers are being utilized. Consequently, it may contain a significant concentration of ammonium ion (as ammonium nitrate). Ammonia will be evolved during caustic addition to the RCT as described by the following stoichiometry:

\[
\begin{align*}
\text{NH}_4\text{NO}_3 + \text{NaOH} & = \text{NH}_4\text{OH} + \text{NaNO}_3 \\
\text{NH}_4\text{OH} & = \text{NH}_3 + \text{H}_2\text{O}
\end{align*}
\]
6.5 PROCESS SUPPORT SYSTEMS

This section provides a description of major DWPF process support systems. Process and analysis control, process instrumentation, process control and the central control room are summarized, as well as process analytical and sampling facilities.

6.5.1 PROCESS AND ANALYSIS CONTROL

DWPF operation is assisted by computer-aided systems for process and analysis control and product waste form compliance tracking. The three major systems are called Process Information Management System (PIMS), Laboratory Information Management System (LIMS), and Product Composition Control System (PCCS). None of these systems interacts with the operation and none is required to operate the plant.

6.5.1.1 Process Information Management System (PIMS)

PIMS is a computer system that retrieves, processes, stores, and displays selected DWPF process data from the DCS and other DWPF computer systems. It resides on the SRS Local Area Network (LAN) where it provides an interface to all authorized users.

6.5.1.2 Laboratory Information Management System (LIMS)

LIMS is a separate computer system which processes, analyzes and records laboratory data. The LIMS can perform calculations, round off results as required, and check data against set limits.

6.5.1.3 Product Composition Control System (PCCS)

The PCCS is a statistical process control software system. Its major function is to judge the acceptability of the melter feed (SME product) to produce glass that meets certain product quality constraints as specified in the Waste Acceptance Product Specifications (WAPS).

The system also generates reports containing the predicted glass properties of the batch. These reports are included in the canister records as Waste Acceptance documentation. The PCCS and its part in ensuring glass quality is discussed in Reference 4.

6.5.2 PROCESS INSTRUMENTATION AND CONTROL SYSTEM

The instrumentation and control system is designed to provide efficient and controllable operation of all processes. To accomplish this, the design of each control instrument and process control loop was selected to achieve a high degree of durability and reliability in its particular application. To the extent possible, sensors, electronic components, and similar devices are located out of the main process cell where they can be readily maintained.
6.5.2.1 **On-line Measurements**

Measurements systems to monitor the process are provided by on-line instrumentation wherever practical. In addition to providing typical process data such as temperature, specific gravity, flow, and liquid level, on-line instrumentation also provides data on gaseous and liquid effluents from the plant. This instrumentation is described in the applicable System Design Description Document and in Chapter 5. Solution temperatures will range from ambient to atmospheric aqueous boiling unless specifically noted. Estimates of the radionuclide concentrations in process streams are discussed in Section 5.5.1.

6.5.3 **CONTROL ROOM**

6.5.3.1 **DWPF Central Control Room**

The vitrification process is normally controlled from the Central Control Room (CCR) in 210-S, but the distributed control system (DCS) also has the flexibility to allow processes to be controlled separately from local Field Operating Stations (FOS), located in accessible service areas in the 221-S building. FOS-1, located on the 2nd Level, East Corridor, 221-S, is designated as the Backup Control Room, and the entire process can be controlled from there for orderly shut down of each of the process cells if the CCR is unusable.

Specific actions by a control room operator are not required to prevent or mitigate accidents in DWPF (refer to Subsection 5.2.3.10). If an event occurs that requires evacuation (for example, a toxic gas release), the CCR can be evacuated without affecting the safety of the plant.

6.5.3.2 **Deleted**

6.5.4 **SAMPLING - ANALYTICAL**

Process control of the DWPF operations is accomplished by a combination of off-line and on-line analyses. For the most part, samples are taken for off-line analyses in a process control laboratory located in the west corridor on the mezzanine level of the Vitrification Building. Results from these analyses provide the following:

- Information used to control the process in accordance with technical specifications.
- Diagnostic data to aid technical personnel identify cause(s) of process deviations.
- Historical data required to aid technical personnel to evaluate the efficiency of the process and to optimize process performance.
- Verification of the composition of essential materials and batch makeup of cold chemicals.
- Verification of the composition of non-process effluents ensures limits are not exceeded prior to discharge to the environment (Aqueous process waste is returned to the tank farm). This is discussed in Chapter 7.
6.5.4.1 Process Sampling

VITRIFICATION PROCESS LIQUID SAMPLING

Sampling capability is provided for the process vessels listed below. Sample lines connect the vessels to a sampling station. The sampling station is a shielded cell facility that is operated with manipulators, located toward the South end of the shielded cell arrangement. The facility contains several sampling points from a group of process vessels. Samples are obtained by pumping the process solutions through a sample point for a specified period before the sample is isolated. The material being pumped through the line returns to the process vessel where it originates. When sampling is complete, the lines are flushed with water. Flush waters from CPC vessels are sent to the originating vessels or to the RCT located in the CPC of Building 221-S.

Samples are collected in a container from sampling stations and identified. The samples are then transported to adjacent shielded analytical cells. Some analyses are performed remotely using equipment installed in the cells. Other samples, requiring specialized equipment, are performed in the analytical laboratory. These samples require dilution before removal from the shielded cells to reduce radiation levels. After samples have been treated and appropriately diluted, the samples are transported to a shielded glove box in the analytical laboratory. A radiation detector is positioned to verify acceptable radiation levels.

LIQUID SAMPLE POINTS

Liquid or slurry process samples may be taken from the following vessels. Additional details of the sampling systems are located in Reference 19.

- Slurry Mix Evaporator (SME)
- Slurry Mix Evaporator Condensate Tank (SMECT)
- Sludge Receipt Adjustment Tank (SRAT)
- Melter Feed Tank (MFT)
- Off-Gas condensate Tank (OGCT)
- Backup Off-Gas condensate Tank (BUOGCT)
- Recycle Collection Tank (RCT)
- Decontamination Waste Treatment Tank (DWTT)
- Strip Effluent Feed Tank (SEFT)
- Precipitate Reactor Feed Tank (PRFT)

ANALYTICAL CELLS

The analytical cells contain laboratory and analytical equipment used to process samples that are too radioactive for direct analysis. The equipment is operated by the use of manipulators.
ANALYTICAL AND ORGANIC LABORATORIES

The laboratories are equipped to analyze process control samples that have been diluted to manageable levels of radioactivity in the analytical cells.

6.5.4.2 Process Support Sampling

CHEMICAL ANALYSES

Purchased chemicals and batch makeup chemical solutions are analyzed as required. Process effluents are sampled and analyzed before they are released to the environment. Sampling points are designated, and guides for releases are provided.

6.5.4.3 Operating Considerations

Process sampling systems are designed and operated to ensure radiological and industrial safety under both normal and abnormal conditions. Design features and procedural controls are provided to maintain safe operation of the process sampling systems.

RADIOLOGICAL SHIELDING

Process sampling stations are designed to provide radiation shielding that will limit personnel exposure in the operating areas to less than 0.5 mrem/hr.

REMOTE OPERATION

Sampling operations, including collection, packaging, identification, and transfer of all high level samples from the process cells, are conducted within the shielded enclosure of each sample cell with the assistance of manipulators. Equipment and systems within the cell are designed for remote operation, repair, and replacement. Materials, waste, and equipment removed from the cells are shielded as needed to provide personnel protection.

PREVENTION OF LOSS OF CONFINEMENT

The sample cells and analytical cells are maintained at a negative pressure relative to that of the occupied areas to prevent the migration of airborne radioactivity from the cells into occupied areas. Samples, failed laboratory equipment, waste, and other materials are removed from the sample cells, packaged, surveyed, and transported through transfer stations with controlled ventilation air flow to ensure any airborne particulate radioactivity that may be present is controlled during these operations. Liquid wastes generated in the analytical laboratory are contained and drained to the RCT. Provision for flushing and decontaminating the sample cells and the laboratory drain system are included in the design.
SAMPLE PIPING

The process sample piping is designed so that all sample lines are contained within the shielded walls of the sample cells or the canyon shielding walls. Sample lines drain to the process vessels or to the appropriate waste drain system at the completion of sampling.

PROCEDURAL CONTROL

All sampling is done under approved procedures. The sample size of radioactive process materials is limited to the minimum quantity required for valid stream representation and analytical accuracy.

6.5.5 ANALYTICAL LABORATORY FACILITIES

Most of DWPF samples are analyzed in the analytical laboratory in Building 221-S. Dilutions of highly radioactive samples from the analytical cells are received in the laboratory through the shielded glove box; grab samples from various outside facilities, including cold feeds and effluents, are received on a "walk-in" basis. The samples are analyzed within ventilated hoods and radio benches located in the laboratory. Excess radioactive sample portions are disposed of in a high level waste header which returns the waste to the RCT.

In addition to the Building 221-S laboratory, existing hot cell facilities in Building 773-A are used for some highly specialized analyses, such as glass samples and isotopic analyses of sludge. These are transported in shielded casks.
6.6 SAFETY AND HAZARDS ANALYSIS

Chapter 9, Hazards and Accident Analyses, contains the details of the hazard and accident analyses for DWPF. Chapter 7 discusses the waste management programs and emissions, and Chapter 8 contains summaries of the hazards analysis program, safety program and radiological protection program. Chapter 13 discusses hazards, accidents and the DWPF emergency response program.
6.7 REFERENCES


2. Deleted.

3. Deleted.

4. DWPF Waste Form Compliance Plan. WSRC-IM-91-116-0.


10. Deleted.

11. Deleted.

12. Deleted.


15. Deleted.


20. Deleted.

22. Deleted.

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27. **Lewis, M.C. and East, J.M. SRS High Level Waste Chemical and Radiological Consequence Analysis Comparison (U).** S-CLC-G-00280, Rev. 0.


30. **Application of Screening Methodology for Selecting Important Chemicals for Inclusion in the DWPF SAR Accident Consequence Analysis (U).** S-CLC-S-00012, Rev. 0.

31. **Screening of DWPF Process Inventory Chemicals (U).** M-CLC-S-00463, Rev. 1.

Figure 6.1-1 512-S Flow Sheet
Figures 6.1-2 and 6.1-3 - Deleted
Figure 6.1-4  Melter Feed Receipt, Blending, Adjustment and Mercury Recovery
FIGURE 6.1-6 Vitrification and Melter Off-Gas Treatment
Figure 6.1-9 Collection and Treatment of Waste Streams
Figure 6.1-10 Process Vessel Ventilation System

FAVC - Formic Acid Vent Condenser
DWTT - Decontamination Waste Treatment Tank
SPC - Stalt Processing Cell
PVV - Process Vessel Ventilation
RCT - Recycle Collection Tank
FIG. 6.1-11, Flow Diagram, DWPF
Figure 6.1-12  -  Deleted
<table>
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<th>Stream Component</th>
<th>Sludge Feed (40)</th>
<th>MST/Sludge Solids from 512-S</th>
<th>Strip Effluent from MCU</th>
<th>Recycled via HDB8</th>
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<td>0-5&lt;sup&gt;d&lt;/sup&gt;</td>
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</table>

<sup>a</sup> The soluble components in these streams consist primarily of sodium salts of anionic species. More than 95% of the soluble species are accounted for as sodium hydroxide, sodium nitrite and sodium nitrate.

<sup>b</sup> The insoluble component of sludge slurry is best described as a complex mixture of hydrated metal oxides that were formed when acidic waste was treated with caustic to allow storage in carbon steel HLW waste tanks. Principal species present in the sludge feed are the hydrated oxides of iron, aluminum, manganese, nickel, uranium, thorium and mercury. Trace quantities of other chemicals and fission products are also in the sludge.

<sup>c</sup> Deleted

<sup>d</sup> The insoluble component of recycled waste consists principally of mercury compounds and small glass particles that are generated during vitrification and entrained into melter off-gas. Mercury compounds (less than 0.1 wt% of the total stream) that may be present in the waste are precipitated when caustic is added to allow transfer to a HLW waste tank.

<sup>e</sup> The expected insoluble weight percent of the MST/sludge solids is 5%; however, the feed may be further concentrated such that it can still be pumped by the existing prime mover. Based on performance tests, the existing pump can handle slurries with up to 8% solids concentration.
### Table 6.1-2  Chemical Composition of DWPF Sludge Slurry Feed Used as Basis for Design

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Table 6.1-2  Chemical Composition of DWPF Sludge Slurry Feed Used as Basis for Design
(continued)

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a  Cd, Mo, Rb, Se, Te.
b  Ag, Am, Ce, Cm, Co, Cr, Eu, La, Nb, Nd, Np, Pm, Pr, Sb, Sm, Sn, Tb, Ti, Zr.
c  SiO₂ - 48.0 wt %
    H₂O - 19.1 wt %
    Al₂O₃ - 18.6 wt %
    Na₂O - 4.10 wt %
    CaO - 10.2 wt %
Table 6.1-3  Deleted
Table 6.1-4  Deleted
Table 6.1-5  Deleted
Table 6.1-6 Maximum Chemical Composition of DWPF MST/Sludge Solids Feed (From 512-S) Used as Basis for Design

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FINAL SAFETY ANALYSIS REPORT
SAVANNAH RIVER SITE
DEFENSE WASTE PROCESSING FACILITY

CHAPTER 7
WASTE CONFINEMENT AND MANAGEMENT

November 2018
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7.0 INTRODUCTION

Features used to confine, treat, store, and dispose of radioactive, hazardous, and mixed wastes are described in this chapter. The first Section presents the criteria followed in managing the waste. The second Section presents a summary of waste sources and the principles applied in treating wastes. The following sections provide descriptions of the process directly involved in the management of the wastes, with emphasis on the potential hazards and features included to ensure safety. Principal design criteria, equipment and facilities, and process systems for DWPF are described in Chapters 5 and 6, respectively.

The waste confinement and management functions described in this chapter cover all effluents and byproducts, radioactive, hazardous, and mixed, which are either released to the environment, or are recovered and managed or disposed of onsite. Liquid high level waste feeds sent to DWPF are classified as mixed waste because they contain hazardous and radioactive contaminants. However, once the waste is made into glass, it no longer exhibits any hazardous characteristics.

Vitrified waste and the related processes for producing it are discussed only briefly in this chapter since the glass product is discussed in Section 6.1.7, Melter Operation.
7.1 WASTE MANAGEMENT CRITERIA

Figure 7.1-1 identifies radioactive waste streams and Figure 7.1-2 identifies hazardous and other liquid waste streams from DWPF. Table 7.1-3 lists controls and routing for radioactive effluents.

7.1.1 GASEOUS EFFLUENTS

As a design objective, the quantities of the contaminants released with gaseous effluents are to be As Low As Reasonably Achievable (ALARA) and within the applicable limits of the DOE Orders and state and federal laws and regulations as specified in the following paragraphs.

7.1.1.1 Radioactive Waste Contaminants

The onsite release of airborne radionuclides from DWPF and 512-S, when combined with exposures from other internal and external sources, complies with 10 CFR 835. Release to members of the public, when combined with doses from other exposure pathways, complies with DOE Order 5400.5.

Radioactive discharges from the DWPF to the atmosphere comply with the EPA-NESHAP radionuclide emission standards promulgated by 40 CFR 61, Subparts A and H. The terms and conditions specified by the EPA-NESHAP approval for the DWPF also apply. Design features of the Vitrification Building ventilation systems, the Melter Off-gas System, Low Point Pump Pit and 512-S ventilation systems are discussed in Section 5.2 and Section 5.3.

7.1.1.2 Hazardous and Industrial Waste Contaminants (Air Emissions)

Air pollutant emissions from the DWPF are controlled by the limits of the South Carolina Department of Health and Environmental Control (SCDHEC) Part 70 Air Quality permit # TV-0080-0041 (Ref. 2).

7.1.2 LIQUID EFFLUENTS

7.1.2.1 Radioactive Waste Contaminants

Liquids suspected of being contaminated radiologically are screened. Liquids that do not pass the screening are not released to the environment from DWPF. There are two aqueous recycle streams from the DWPF/512-S to H-Area. Filtrate from 512-S flows to H-Area, where it eventually goes to Z Area as part of the low curie salt solution. Aqueous process liquids (DWPF recycle Interface Stream 10) are collected, treated (Section 6.1.10) and returned to H-Area. These include chemical wastes from the hot analytical laboratories.

7.1.2.2 Hazardous and Industrial Waste Contaminants

Releases of chemicals to the environment are maintained within the limits of the South Carolina Department of Health and Environmental Control (SCDHEC) permits. Design features of the
water effluent system are discussed in Section 5.3.2. The cold chemical feed preparation and waste treatment systems are discussed in Section 5.4.13. These systems are designed to comply with federal, state and local requirements.

Industrial wastewater discharges from DWPF are limited, monitored, and discharged per Section 7.3.2.

7.1.2.3 Mixed Waste Contaminants

No liquids contaminated with radioisotopes of process origin are released to the environment from DWPF. There are two aqueous recycle streams from the DWPF/512-S to H-Area. These streams are discussed in subsection 7.1.2.1.

7.1.3 SOLID WASTES

Solid waste is controlled at the source of generation to reduce or eliminate it whenever possible. Solid waste is treated according to the type and concentration of the contamination involved.

7.1.3.1 Dry Active Waste

Dry Active Waste (DAW) is radioactive-contaminated solid material not classified as either hazardous, transuranic or high level waste pursuant to the requirements of 10 CFR 60. DAW generated during the daily operation of the DWPF is minimized, characterized, packaged, and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

7.1.3.2 Hazardous and Industrial Solid Wastes

Nonradioactive solid wastes are recycled whenever possible or transferred to approved disposal sites in accordance with accepted industrial practices. A DWPF Waste Minimization Program has been developed which complies with the requirements of DOE Order 430.1.

7.1.3.3 Mixed Wastes

Mixed Wastes are managed in accordance with the requirements of Manuals 3Q, Environmental Compliance Manual (Ref. 16) and 1S, SRS Radioactive Waste Requirements Manual (Ref. 20). Long term storage and disposal of mixed wastes is not permitted at DWPF.

7.1.4 WASTE MANAGEMENT SUPPORT ORGANIZATION

Radioactive, hazardous, and mixed waste management at DWPF is the responsibility of the Operations organization, described in Chapter 10, Conduct of Operations. The Waste Certification Plan (Ref. 14), describes the management program for reduction of wastes of all types, and this is updated as required.

The site support organization for control of radiological and hazardous materials at SRS is summarized in Sections 8.1, 8.2, and 8.3. The site support for storage and disposal of solid radiological, hazardous, and mixed wastes is the responsibility of the Solid Waste Division.
7.2 RADIOACTIVE WASTES

The origin and general composition of waste materials generated by DWPF operations are described here. Treatment, handling, storage, and disposal are included.

7.2.1 GASEOUS EFFLUENTS

Ventilation air and gaseous effluents from the process cells, process vessels, and melter are contaminated with radioactivity of process origin. These gases are treated to ensure the concentrations of radionuclides are at acceptably low levels before they are discharged to the atmosphere through stacks. See Figure 7.1-1 for origins of these gaseous wastes. This chapter only addresses the features in the final exhaust stream designed to limit discharge of airborne radioactivity. These features are discussed briefly here and in more detail in Section 5.4.

7.2.1.1 Zone 1 Exhaust System

The Zone 1 exhaust system collects off-gas from the Vitrification Building process areas, process vessels and enclosures, and the melter as well as ventilation air from these potentially contaminated areas. Each source is treated to reduce particulates before being fed to a common plenum. In this plenum, the various off-gas sources merge to a common air exhaust stream. This stream is treated by a sand filter to remove radioactive particulates. After filtration through the sand filter, the air is discharged to the atmosphere through a stack. Collection and treatment systems are discussed more fully in Chapters 5 and 6.

Stack discharges of filtered exhaust air are sampled. The sampling is performed within the requirements of DOE Order 5400.5 and EH-0173T through the implementation of 3Q1-2, Volume 1 (Ref. 16) and Environmental Commitment Matrix Manual (Ref. 1). Radiation sampling for EPA- NESHAPs occurs from the ductwork between the fanhouse and the stack.

7.2.1.2 Zone 2 and Zone 3 Exhaust System

Exhaust air from Zone 3 of the 221-S Vitrification Building cascades to the Zone 2 areas (operating corridors). Air exhaust from Zone 2 areas, the weld test cell, and radiologically controlled shops is potentially contaminated with radioactivity. Exhaust air from each area is discharged into a single exhaust stream. This stream is processed through a common HEPA filtration unit to remove radioactive particulates before it is discharged to the atmosphere through a stack located on the Vitrification Building (Building 221-S) roof. Zone 2 exhaust system equipment that is located upstream of the common HEPA filtration unit is discussed in Chapter 5. Air exhaust from personnel areas is sampled for radioactivity. Continuous Air Monitors (CAMs) and filter air sampling stations are also used in personnel areas to sample and monitor for airborne radioactivity.
7.2.1.3 512-S and Low Point Pump Pit Ventilation Systems

For the process tanks and cells during normal operations at the Low Point Pump Pit (LPPP) and the 512-S, contaminated or potentially contaminated gaseous effluents are collected in the Pump Pit Ventilation (PPV) and 512-S Process Vessel Ventilation (PPV) systems, respectively, and filtered through sets of HEPA filters. The maintenance and service areas and open cells in the maintenance mode are directed through HEPA filters in the Maintenance and Service Area Exhaust systems. A complete description of this system can be found in Chapter 5.

7.2.2 LIQUID WASTES

The radioactive aqueous wastes generated by DWPF and 512-S operations are returned to H-Area (via the interarea transfer lines, Section 5.2) for further treatment. Interface agreements, developed between S-Area and H-Area, provide limits for returning wastes to comply with the receiving facility’s Waste Acceptance Criteria (WAC) (Ref. 9). Wastes are analyzed and adjusted as necessary before being returned to H Area. The only liquid byproduct generated at the DWPF is mercury. Mercury is reclaimed and is discussed in Section 5.2.3.5 and Section 6.1.9.

7.2.2.1 Aqueous Liquid Wastes

Most of the aqueous radioactive waste in DWPF is rinse water streams, process cell sumps, flushing wastes and condensate from the vitrification process. In addition, some radioactive wastes are generated from chemical solutions and rinses used in the Analytical Laboratory and in decontamination of process and maintenance equipment. All of these waste streams are collected in the Recycle Collection Tank, where they can be treated appropriately to meet Waste Acceptance Criteria (WAC) requirements for transfer of these wastes to H-Area for treatment and recycling. Radioactive liquid waste generated at the 512-S is collected in the Late Wash Hold Tank (LWHT). The LWHT waste (filtrate) is transferred to the Modular CSSX Unit (MCU) for processing and/or disposal as applicable.

There is no discharge to the environment of liquid waste that does not pass a radiological screening. Recycle waste stream sources and the equipment for treating them are discussed in Sections 5.2.3.7, 6.1.10 and 6.4.7. Figure 7.1-1 graphically depicts the sources and routing.

7.2.3 SOLID WASTE

Canisters of glass, DWPF’s principal product, must meet the waste form requirements in the Waste Acceptance Product Specifications (WAPS). Items and activities important to DWPF’s compliance with the WAPS are identified and controlled by the DWPF Waste Form Compliance Plan (Ref. 5).

The canisters are stored in one of the Glass Waste Storage Buildings (GWSBs). Radioactive decay heat from around the canisters is removed by the natural circulation of air. The exhaust air discharges to the atmosphere. Refer to Section 5.3.2.4 for details of the GWSBs.
The design life expectancy of the glass melter is two years. Residual glass in the melter requires it to be classified as nonhazardous radiological waste. Therefore, failed melters will be stored in the Failed Equipment Storage Vault, 260-S (Section 5.3.2.10).

7.2.4 DRY ACTIVE WASTE

To facilitate handling operations at SRS, Dry Active Waste (DAW) is classified as low level and intermediate level beta-gamma radioactive waste. Intermediate level radioactive waste is defined as any solid waste with radiation levels equal to or greater than 200 mrem/hr at 5 cm from the surface of an unshielded package. Low level radioactive waste is defined as any waste from a controlled area with radiation levels less than 200 mrem/hr at 5 cm from the surface of an unshielded package. Operations procedures ensure that each type of waste is handled in accordance with its level of radiation, and that personnel exposures are kept as low as reasonably achievable (ALARA).

Solid wastes generated at DWPF are minimized, characterized, packaged, and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20). The origin of the DWPF DAW is discussed below.

7.2.4.1 Contamination Control Waste

Contamination control waste is generated during work performed by personnel in controlled areas. It consists of discarded protective clothing, gloves, shoe covers, plastic sheets, cellulose wipes, etc. It is packaged and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

Great effort has been made to avoid generating mixed wastes. Use of any solvents in maintenance work that would result in mixed waste has been prohibited by maintenance procedures and the Waste Certification Plan (Ref. 14). However, laboratory work may result in solvent-containing wipes, which will be bagged separately and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

7.2.4.2 Ventilation Filters

Dust-stop and HEPA filters are extensively used in the ventilation and off-gas systems in the DWPF. The removed filters are classified as DAW. They will be disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20). Alternatively, these dust-stop and HEPA's as well as spent process off-gas HEME and HEPA filters may be treated to minimize DAW volume by chemical dissolution, using the Decontamination Waste Treatment Tank (DWTTr) in 221-S. The process will dissolve the filter media, leaving the metallic frame to be disposed of as failed process equipment if it is still contaminated. The dissolved filter media will be suitably treated and sent to the RCT for transfer to H-Area.
7.2.4.3 Failed Process Equipment

Major process vessels have a limited life expectancy based upon design criteria and SRS equipment histories. All of these are remotely replaceable, as are the connecting piping and instruments. Failed process equipment will be removed, decontaminated to the extent practicable and stored as failed process equipment. Manual 5Q, Radiological Control (Ref. 22) and Manual 5Q1.1, Radiation and Contamination Control (Ref. 23) discuss planning and procedural requirements for this work.
7.3 HAZARDOUS AND INDUSTRIAL WASTES

The operation of the DWPF generates quantities of hazardous and industrial liquid, gaseous, and solid wastes. This Section discusses the source, treatment processes, and discharge points for effluents released to the environment. See Table 7.1-2 and Figure 7.1-2 for sources of hazardous and industrial liquid wastes.

7.3.1 GASEOUS EFFLUENTS

7.3.1.1 Cold Feed Preparation Ventilation Systems

A single ventilation system is provided to direct discharge of chemical vapors through high efficiency filters to an elevated exhaust located on the Building 221-S roof near the Zone 2 stack. Two tank ventilation systems are provided in 422-S outside facilities to direct discharge of chemical vapors and particulates to the environment through high efficiency filters. The high efficiency filter removes most particles, and the HEPA filter removes the submicron particles from the off-gas.

COLD FEED TANKS - VITRIFICATION BUILDING 221-S

Separate vent paths are used to segregate organic acid vapor and other chemical vapors in Building 221-S cold feed tanks. Formic acid vapor collected from the 90% formic acid feed tank is vented to the 221-S roof. The following tanks are vented directly to the cold feed vent header:

- Nitric acid dilution tank
- Nitric acid decon feed tank
- Nitric acid feed tank
- Caustic feed tank
- Sodium nitrite feed tank
- Oxalic acid decon feed tank
- Decon frit slurry feed tank
- Process frit slurry feed tank
- Off-gas chemical feed tank
- Process cooling water head tank
- Process chilled water head tank
- Melter cooling water hold tank
- Process steam condensate hold tank
- Additive mix/feed tank
- Organic Acid Drain Catch Tank
• Floor Drain Catch Tank
• Acid Drain Catch Tank

The gases in the cold feed vent header are filtered and discharged through an exhaust near the Zone 2 exhaust stack located on top of Building 221-S.

COLD FEED CHEMICAL MAKEUP FACILITY BUILDING 422-S

Two separate vent systems are provided in the cold feed preparation area. The formic acid dilution tank, dilute formic acid feed tank, frit slurry makeup tank, and oxalic acid make up tank are vented to the organic acid vent system.

The following tanks are vented to the acid vent system:

• Nitric acid decon makeup tank
• 50% nitric acid portable storage tank
• Decon solution makeup tank
• Potassium nitrate makeup tank
• Boric acid makeup tank

The Sodium Nitrite Makeup Tank will be vented and filtered as required by the Industrial Hygiene Program.

Gases from each system are filtered and discharged to the atmosphere by a blower. The caustic storage tank is vented through a gooseneck to the atmosphere, and the hydroxylamine nitrate storage tank (currently not used at DWPF) is vented to the atmosphere through a conservation unit.

Tanks containing concentrated formic acid are nitrogen blanketed and equipped with safety relief valves for pressure relief under extreme temperature conditions.

7.3.1.2 Chemical Waste Neutralization Facility (980-S) Vent

The chemical waste neutralization facility provides for the neutralization and permitted disposal of nonradioactive chemical and industrial liquid wastes from the DWPF. The chemical waste neutralization system tanks listed below vent to the atmosphere:

• Caustic waste neutralization tank No. 1
• Caustic waste neutralization tank No. 2
• 8% nitric acid mix/day tank
• Acid waste hold tank
• 5% caustic mix tank
7.3-3

- 5% caustic day tank
- Organic acid waste neutralization tank No. 1
- Organic acid waste neutralization tank No. 2

The organic neutralization tanks are provided with flame arrestors in their vent lines.

7.3.1.3 Diesel Exhausts

Diesel-driven water pumps and generators are provided to ensure operation of critical equipment in the event of loss of normal power. There are two diesel generators in 292-S, two diesel drives for the water wells, and one diesel-driven water pump for fire fighting, all of which exhaust to the atmosphere.

7.3.2 LIQUID EFFLUENTS

Nonradioactive wastes, consisting of chemical, industrial and sanitary streams generated at the DWPF, are monitored, collected, and treated, if necessary, before discharge to the environment. Sources and routing of these streams are indicated in Figure 7.1-2. The neutralized effluents from the chemical waste treatment facility are sampled for radioactivity. The cooling water systems and waste effluents are illustrated in Figure 7.1-3.

Facilities are provided to treat batches of chemically contaminated wastewaters before they are discharged to the environment. Hold tanks are provided for the caustic and various acid wastes. The effluents are neutralized by controlled blending of the caustic and acid wastes as much as possible. Otherwise, chemical agents are added to neutralize the waste before discharge.

The floors of the treatment system areas are diked to isolate the chemically contaminated wastewater from each system. The hold tank and neutralization tank overflow lines are sealed to prevent vapor releases through the overflow lines.

Release of the neutralized wastes with the cooling tower blowdown is regulated to render the resultant waste stream acceptable for discharge to the environment through the Central Sanitary Wastewater Treatment Facility. Industrial wastewater discharges from DWPF are limited and monitored as required by the Central Sanitary Wastewater Treatment Facility.

7.3.2.1 Chemical and Industrial Waste Treatment

The chemical and industrial waste treatment system provides pH treatment of nonradioactive chemically contaminated wastewaters from chemical spills, drains, overflow, flushing, and washdown in cold feed and process areas.

The chemical and industrial waste treatment system consists of:

- Piping used to transfer acid, caustic, organic wastes, and treatment chemicals to the treatment station
- Chemical waste storage and treatment facilities
- Treated waste disposal facilities

CAUSTIC AND ACID WASTE TREATMENT SYSTEM

Caustic and acid waste from the cold chemical operations in the Vitrification Building, bulk frit and cold feed storage areas, and the primary water treatment building are separately collected and transferred to the waste treatment area (980-S). Sumps from 512-S Cold Chemical Storage Area are pumped out to carboys or water buffaloes and brought to 980-S for processing. Acid waste is stored in the Acid Waste Hold Tank. Caustic waste is stored in the Caustic Waste Neutralization Tanks. The 980-S facility permits controlled blending for neutralization with additional NaOH or HNO₃ to render the waste acceptable for disposal to the environment. The neutralized waste is discharged into the cooling tower blowdown stream for disposal.

ORGANIC ACID WASTE TREATMENT SYSTEM

Organic acid waste from the Vitrification Building and the bulk frit and cold feed storage areas is collected and transferred to the organic waste neutralization tanks. The oxalic acid sump in 512-S Cold Chemical Storage Area can be pumped out to carboys or water buffaloes and brought to 980-S for processing in the organic acid waste neutralization tanks. Neutralization of the waste involves controlled blending with NaOH. The neutralized waste is discharged into the cooling tower blowdown stream for disposal.

7.3.2.2 Storm Sewers

The storm sewers provide a total system for the collection and disposal of storm water runoff. The storm sewers consist of a gravity flow collection system designed to remove surface runoff from the open areas and building roof drains.

All surface runoff is collected in a ditch and pipe system, and is ultimately discharged to nearby surface streams. Erosion is minimized throughout the system by providing reinforced concrete headwalls with properly graded and riprapped ditches and banks. The Programmatic Stormwater Guidelines and Requirements contained in the Environmental Compliance Manual (Ref. 16) details regulatory and control requirements.

7.3.3 SOLID WASTE GENERATION

Nonradioactive solid wastes are generated in the DWPF in clean (non regulated) areas. These wastes are collected and transported to a designated disposal site. Ordinary paper waste is collected for recycle or placed in a landfill or rubble pit where it is compacted and covered. Other solid wastes (scrap metal, etc.) are collected, segregated, and sold as salvage.

Nonradioactive solid wastes for the DWPF are typical of any non-nuclear industrial wastes and are handled in the same manner. Most of this type of waste is collected from offices, lunchrooms, restrooms, non regulated utility buildings, and non regulated storage buildings. System Operating Manuals and administrative controls are used to maintain segregation of regulated and
non regulated solid wastes. Nonradioactive solid wastes are collected and sorted where practical into disposable and salvageable components. Solid chemical wastes are physically isolated and packaged for disposal per approved procedures. Waste minimization principles are applied in all activities from generation to disposal of waste. These are described in the Waste Certification Plan (Ref. 14) which is updated as required.
7.4 MIXED WASTES

7.4.1 CONTAMINATION CONTROL WASTES

Great effort has been made to avoid generating mixed wastes. Use of any solvents in maintenance work that would result in mixed waste has been prohibited by maintenance procedures and the Waste Certification Plan (Ref. 14). However, laboratory work may result in solvent-containing wipes, which will be bagged separately and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).
7.5 LIQUID RADIOACTIVE WASTE TREATMENT AND RETENTION

All liquid wastes of process origin except mercury are processed to a suitable form in the DWPF and sent to H-Area. The waste is further treated at H-Area and insoluble solids are eventually returned as DWPF process feed. Because of this recycling design feature, the vitrification process has only mercury as a radioactive liquid effluent stream. Mercury may be decontaminated and purified as required. The liquid waste collection and treatment equipment and process are discussed in Sections 5.2.3 and 6.1.10 and indicated in Figure 7.1-1. Mercury collection and purification is discussed in Sections 5.2 and 6.1.9. Design objectives for the liquid waste treatment and retention system are described in Chapter 5.
7.6 LIQUID WASTE SOLIDIFICATION

All aqueous wastes of process origin are sent to H-Area for further treatment. A system to solidify secondary waste streams is not necessary for DWPF.
7.7 DRY ACTIVE WASTE

Dry Active Waste (DAW) generated during the operation of the DWPF is appropriately characterized, packaged, and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20) as either intermediate level or low level DAW as discussed in Section 7.2. The primary criteria is to remove as much of the radioactivity as possible, to avoid the release of the radioactivity to the atmosphere, and to dispose of the waste while keeping personnel exposure as low as reasonably achievable (ALARA).

7.7.1 PACKAGING

Low level DAW is segregated into compactible and non-compactible containers. Compactible and Non-compactible waste is packaged and disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20). Records are completed for each container of contaminated waste that identify the radioactivity, date, source, and type of radiation. Waste is characterized as required by Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

Intermediate level DAW consists primarily of failed process equipment. Failed process equipment is typically decontaminated, packaged, and transported per Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

7.7.2 EQUIPMENT AND SYSTEMS DESCRIPTION

Failed process equipment is removed from the remote process cell by the use of the remotely operated main process cell crane. It is then decontaminated, packaged, and disposed per Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20). There are no permanently installed systems to process DAW. The vitrification equipment decontamination and repair facilities are discussed in Section 5.2.

The packaged radioactive waste (contamination control wastes, filters, etc.) is disposed according to Manual 1S, SRS Radioactive Waste Requirements Manual (Ref. 20).

7.7.3 STORAGE FACILITY

There are no permanently installed storage facilities in DWPF to store DAW.

7.7.4 CHARACTERISTICS, CONCENTRATION, AND VOLUME OF SOLID WASTE

Waste is characterized as required by Manual 1S, SRS Radioactive Waste Requirements Manual. The estimates are based on the following assumptions:

1. Failed melters will be stored as HLW in the failed equipment storage vault until a permitted offsite storage facility is available.

2. The curie content for other wastes is based on SRS experience with similar materials.
3. The volume of failed process equipment (other than the melter) assumes a life expectancy of 20 years.

4. The volume of filters assumes the dust-stop filters are changed every 6 months and the HEPA filters every 2 years.

5. The volume of contamination control waste is based on experience at other SRS facilities.

Sources for the estimates are identified in Reference 11.

7.7.5 ITEMS REQUIRING FURTHER DEVELOPMENT

The DWPF process results in failed process equipment that may contain high level wastes, primarily the HLW melter which has a limited life. Since DOE has not identified a permanent HLW disposal facility for such waste, these items must be stored safely onsite in an interim storage facility such as the Failed Equipment Storage Vault, an engineered below-grade shielded storage facility, which is described in Section 5.3.2.

Permanent disposition of this contaminated failed equipment requires further development and is beyond the scope of this FSAR. Interim storage has been developed and is recognized in the DWPF Final Supplemental EIS (Ref. 11) as a means to provide safe interim storage of this equipment until a permanent disposal facility can be identified.
7.8 REFERENCES

2. SCDHEC Part 70 Air Quality Permit. TV-0080-0041.
3. Deleted.
4. Deleted.
5. DWPF Waste Form Compliance Plan. WSRC-IM-91-116-0.
7. Deleted.
8. Deleted.
12. Deleted.
15. Deleted.
19. DWPF System Design Description (U), Hg Purification and Analytical Facility. G-SYD-S-00037.

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Process Interface Controls for Radioactive Effluent Streams
(Ref. 10)

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Figure 7.1-1 Radioactive Waste Streams, DWPF
Figure 7.1-2 Non-Radioactive Liquid Waste Streams, DWPF
Notes:

1. Indicates that these valves close for environmental protection from radioactive contamination.

2. Indicates that these valves open for environmental protection from radioactive contamination.

CSWTF – Central Sanitary Wastewater Treatment Facility

Figure 7.1-3. Cooling Water Systems and Effluents, DWPF
FINAL SAFETY ANALYSIS REPORT
SAVANNAH RIVER SITE
DEFENSE WASTE PROCESSING FACILITY

CHAPTER 8
FACILITY SAFETY PROGRAMS

November 2018
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8.0 FACILITY SAFETY PROGRAMS

The programmatic elements of the Defense Waste Processing Facility (DWPF) safety programs are described in this chapter as follows:

- Radiological Protection (Section 8.1),
- Industrial Hygiene (Section 8.2),
- Industrial Safety (Section 8.3),
- Fire Safety (Section 8.4), and
- Nuclear Criticality Safety (Section 8.5).
8.1 RADIOLOGICAL PROTECTION PROGRAM

This section provides information on the SRS radiological protection program applicable to DWPF. Section 8.1.1 provides information regarding management policy and organization to ensure that radiation exposures are "As Low As Reasonably Achievable" (ALARA). Section 8.1.2 describes methods and systems used. Section 8.1.3 describes sampling and monitoring of potential releases of radioactive material to off-site. Section 8.1.4 provides information on the administrative organization, program objectives, equipment, instrumentation, facilities, administrative control procedures, respiratory protection and occupational radiation exposure.

8.1.1 ORGANIZATIONAL AND POLICY CONSIDERATIONS

It is the policy of the prime operating contractors for SRS to maintain radiation exposures to levels that are ALARA. The design criteria for ALARA used during the original design of DWPF were contained in federal documents that existed during the 1975-83 design phase. FSAR Chapter 5.0 provides the details of design consideration for radiation safety.

Since design completion, the Department of Energy (DOE) has provided requirements and guidance on ALARA programs. The SRR Standards/Requirements Identification Documents (S/RIDs) (Ref. 25) state the codes, standards, and regulations governing the radiological protection policies and program elements of the SRS. Programmatic compliance assessments have been performed against the S/RIDs and documented as specified in Manual 8B, Compliance Assurance Manual (Ref. 2). The Standards Management/Compliance Section maintains records of programmatic compliance assessments.

The requirements of these documents are implemented at DWPF via Technical Safety Requirements (TSRs), the site Radiological Control Manual 5Q (Ref. 1), lower tier procedures, and other site procedures and manuals.

Commitment to ALARA is required by Manual 5Q1.1 for all levels of employees (Ref. 29). The President of the SRS prime contractors, through the Radiological Advisory Committee, establishes the radiological performance goals. The Site ALARA Committee and its subcommittees provide a multidiscipline forum of the department/facility line organizations and support functions. The purpose, organization, and function of committees responsible for radiation safety is stated in SCD-6, SRS ALARA Manual (Ref. 10). ALARA reviews are performed for DWPF radiological design changes, modifications, operation and maintenance procedures per requirements of Manual 5Q1.1 (Ref. 29).

8.1.2 OPERATIONAL CONSIDERATIONS

The Radiological Work Permit (RWP) is the primary administrative mechanism used to establish radiological controls for intended work activities in radiological areas and for handling of radioactive materials. The RWP informs workers of area radiological conditions and entry requirements and provides a mechanism to relate worker exposure to specific work
activities. The RWP program has been implemented in accordance with the requirements of Manual 5Q1.1 (Ref. 29).

The requirements in Manual 5Q provide the system to ensure that radiation, contamination, and airborne radioactivity are controlled to appropriate levels. Controls required range from providing routine radiological surveys to prohibiting personnel access. Controls in between these two extremes provide for careful monitoring of radiation exposure and the wearing of personal protective equipment.

Installed instrumentation that measures radiation and airborne radioactivity also provides a means to ensure that radiation exposure is controlled. Routine source checks, operational checks, and calibrations are performed on these instruments per approved procedures.

Personnel training requirements are provided in the Manual 5Q (Ref. 1) for area employees, radiation workers, and Radiological Control Inspectors. This includes general site training as well as facility-specific training.

8.1.3 ENVIRONMENTAL MONITORING PROGRAMS (SITE-WIDE)

The SRS environmental monitoring program for radioactive releases is extensive and various release pathways are monitored for radioactivity. Details of these programs, including sampling locations and frequencies, are given in the SRS Environmental Monitoring Plan, Manual 3Q1-2 (Ref. 11). The effluent and environmental monitoring equipment, instrumentation, and facilities specific to DWPF are detailed in Section 5.2.3.13.

8.1.4 RADIOLOGICAL PROTECTION PROGRAM

A description of the components of the Radiological Protection program at the SRS and DWPF is contained in the following subsections. Included are descriptions of the program organization, program objectives, equipment, instrumentation, facilities, administrative controls, training, review and audits, and inspection and testing of equipment.

8.1.4.1 Program Organization

The radiological protection organization is the responsible consulting authority within SRS for radiation protection of plant personnel and the public. It is responsible for awareness, analysis, and advice to other departments on health hazards incident to the handling, use of, and exposure to radioactive materials. It is also consulted for guidance in radiation protection of Savannah River Site employees, equipment, and environment. However, total responsibility for radiation safety at the SRS rests with departmental line organizations.

A sufficient level of Radiological Control (RC) staff is maintained at DWPF and at SRS to ensure that the goals of the Radiological Protection program are maintained. Personnel associated with the Radiological Protection Program must have a combination of education, experience, and training in order to perform their duties. The education, training, and
qualification requirements of Radiological Control personnel are described in the Manual 5Q, Radiological Control Manual (Ref. 1).

General responsibilities of RC personnel at the DWPF are to ensure radiological aspects of operations are conducted in accordance with plant policies and procedures, to provide information and advice concerning radiation safety, to ensure that environmental protection is effective, and to maintain records to assist in the general program to maintain personnel exposure within ALARA guidelines.

8.1.4.2 Program Objectives

The Radiological Protection Program objectives are to:

- Minimize radiation exposure of personnel and prevent or limit skin contamination
- Prevent internal assimilation of radioactive material
- Minimize contamination of facilities
- Minimize the release of radioactivity to the environment
- Train exempt and nonexempt RC personnel in radiological work
- Provide quality assurance/control on the various procedures and equipment to ensure proper implementation of Radiological Protection programs and operations
- Measure and record personnel radiation exposures

Details of the Radiological Protection Program objectives are provided in Manual 5Q (Ref. 1).

8.1.4.3 Equipment, Instrumentation and Radiological Control Facilities

This section describes the portable and laboratory equipment and instrumentation for radiation monitoring and sampling. The radiological protection facilities, laboratory facilities for radioactivity analyses, protective clothing, respiratory protective equipment, and decontamination facilities are also described.

FACILITIES

DWPF maintains Radiological Control Operation offices, laboratories, decontamination stations, and change rooms. Protective clothing is available at local contamination area access points as required. Change facilities are also provided for those areas where and when personnel traffic warrants. Such facilities consist of clothing storage, count rate meter stations, and other radiological support equipment storage, as appropriate for the job in progress.
RADIOLOGICAL CONTROL INSTRUMENTATION

Laboratory Instrumentation

Laboratory instrumentation allows plant personnel to measure the amount of radioactive material present in samples. Typical samples include contamination survey smears, air sample filter papers, and liquid samples. DWPF laboratory instrumentation includes counters for alpha and beta-gamma emitting samples.

Whole Body Counting Instrumentation

Personnel are monitored in a site whole body counter (e.g. FAST SCAN) at intervals established by procedures or by specific request of Radiological Control.

Portable Survey Instrumentation

Portable survey instrumentation includes radiation survey instruments, monitors for personal survey at exits from controlled areas, equipment used to obtain air samples, laboratory and counting room instruments, and special monitors and instruments for specific jobs. Portable survey instrumentation are maintained and used in accordance with the requirements of Manual 5Q1.2 (Ref. 30).

Personnel Monitoring Instruments

Personnel monitoring is provided, as necessary, by use of Thermoluminescent Dosimeters (TLDs), Thermoluminescent Neutron Dosimeters (TLNDs), electronic personnel dosimeters, portable survey instrumentation, and other approved devices/methods. The TLDs and TLNDs are analyzed quarterly and at other times when circumstances warrant. This provides the official record of personnel external exposure to beta-gamma and neutron radiation.

Personnel exit survey instrumentation consists of count rate meters and whole body friskers.

Calibration

Portable radiation survey instruments and personnel monitoring equipment are calibrated in accordance with the requirements of Manual 5Q1.2 (Ref. 30).

INSTALLED SAMPLING AND MONITORING EQUIPMENT AT DWPF

The sampling and monitoring equipment installed in DWPF are described in Section 5.2.3.13.

8.1.4.4 Administrative Control Provisions

The Radiological Protection Program objectives are implemented at DWPF through a hierarchy of control measures, either individually or in combination, as follows:

- Engineering Controls - shielding, design, remote manipulations, ventilation
• Administrative Controls- dose limits and monitoring, access control, work planning and control, postings, procedures
• Personnel Protective Equipment (respirator, protective clothing)
• Effective Training and employees communications

Engineering considerations for radiation safety are described in Chapters 4, 5, and 6 of the FSAR.

Manual 5Q (Ref. 1) sets forth the practices for the conduct of radiological control activities at SRS. The requirements and administrative controls of Manual 5Q have been implemented at DWPF. These controls include dose limits, surveys, establishing radiological areas, barricades, posting, monitoring, work planning and controls, and training.

Administrative Control Levels are established at challenging numerical levels that are more stringent than regulatory limits. This is done to administratively control and help reduce individual and collective radiation dose. These control levels are multi-tiered with increasing levels of authority required to approve higher Administrative Control Levels.

Planned special exposures (non-emergency) that would result in an individual exceeding any Exposure Guides or Limits are allowed in highly unusual situations where alternatives that would avoid exceeding limits are unavailable or impractical. Such planned special exposures, together with the annual occupational dose received or anticipated to be received in that year, must not exceed the next higher more restrictive limit without appropriate approval. The planned special exposures are approved in accordance with the requirements of the Manual 5Q (Ref. 1).

To ensure that radiation and contamination control programs are adequately protecting both occupational workers and visitors, a dosimetry program has been established at DWPF. Activities associated with the dosimetry program (both external and internal) are maintained in accordance with the requirements of Manual 5Q (Ref. 1).

Control of radioactive contamination is achieved by using engineering and administrative controls, worker performance to contain contamination at the source, reducing existing areas of contamination and promptly decontaminating areas that become contaminated.

Radiological posting alerts personnel to the presence of radiation and radioactive materials and to aid them in minimizing exposures and preventing the spread of contamination. Entrance points to areas of ongoing work activities controlled for radiological purpose state the basic entry requirements. Entrances or access points to a High Radiation or Very High Radiation area have physical controls to prevent inadvertent or unauthorized entry. These physical access controls are defined in Manual 5Q (Ref. 1).

General Employee Radiological Training is required for all SRS employees as part of the SRS General Employee Training. Workers whose job assignments require access to Radiological Buffer Areas (RBAs) shall complete DOE standardized core Radiological Worker Training and
site Radiological Worker Training before being permitted to enter these areas without a qualified escort.

Details of the requirements, implementation plans, and procedures for administrative controls, protective equipment, and radiological training are provided in Manual 5Q (Ref. 1) and in the Radiological Control implementing procedures.

8.1.4.5 Respiratory Protection

It is a SRS policy to protect employees from exposure to airborne radioactive contaminants by using facilities and equipment with physical barriers and other safeguards incorporated into their design. This is the preferred method of protection. When engineering controls are not feasible, or while they are being initiated, protection is provided through a combination of administrative controls and approved respiratory devices. Additional information on the respiratory protection program is addressed in Section 8.2 of this FSAR.

8.1.4.6 Occupational Radiation Exposures

Radiological goals are established annually by the DWPF management in consultation with the ALARA Committee. The establishment and maintenance of goals, their periodic review, and comparison with actual data are methods for tracking the progress toward reducing exposures ALARA. These goals are established and maintained per SCD-6, SRS ALARA Manual (Ref. 10).

8.1.4.7 Record Keeping

Manual 5Q (Ref. 1) requires the establishment of a radiological records management program. This program ensures that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable) and disposition.
8.2 INDUSTRIAL HYGIENE PROGRAM

This section provides information on the SRS Industrial Hygiene program applicable to DWPF. Section 8.2.1 provides information regarding management policy and organization. Section 8.2.2 describes the Industrial Hygiene program. Sections 8.2.3 and 8.2.4 describe identification and evaluation of hazards. Sections 8.2.5, 8.2.6, and 8.2.7 discuss exposure control measures, medical monitoring, and record keeping requirements, respectively.

8.2.1 ORGANIZATIONAL AND POLICY CONSIDERATIONS

8.2.1.1 Industrial Hygiene Policy

The SRS industrial hygiene policy, set forth in the Policy Manual 1-01 (Ref. 3), is to provide a place and condition of employment that is free from, or protected against, recognized hazards that cause or are likely to cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers. This occupational health objective is achieved through a professional, comprehensive Industrial Hygiene (IH) program based on management commitment and employee involvement, worksite analysis, hazard identification, hazard prevention and control, and safety and health training.

Industrial Hygiene programs comply with prescribed codes, standards, regulations, and guidelines as specified in the S/RIDs (Ref. 25) and 4Q Manual (Ref. 13).

8.2.1.2 Industrial Hygiene Organization

A qualified IH staff of professionals and technicians supports the implementation of the IH Program of 4Q Manual (Ref. 13). The Industrial Hygiene group provides DWPF with assistance on technical matters relating to industrial hygiene and implementation of the IH Program.

Line Supervision is ultimately responsible for each employee's health and safety. Each employee is responsible for knowing and following the control measures applicable to each job, minimizing exposures, and for being aware of the potential hazards before a job starts.

As described in the Policy Manual, Manual 1-01 (Ref. 3), the Safety and Health Review Committee provides policy/guidance in matters related to the safety and health of the employees.

8.2.1.3 Industrial Hygiene Staff Qualifications

IH staff are qualified in accordance with the requirements of Manual 4Q (Ref. 13). IH staff are trained in anticipating, recognizing, evaluating, and controlling the hazardous exposures. They maintain cognizance and competence in IH science through continual training, professional education, and/or certification. The training is provided according to the assigned tasks and level of responsibilities.
8.2.1.4 Training

Employees at SRS are provided with industrial hygiene-related training so that they can adequately and safely perform work assignments. For those personnel assigned by management, training is provided on lasers, hearing conservation, heat stress, respiratory protection, and hazard communication.

8.2.2 INDUSTRIAL HYGIENE PROGRAM

The Industrial Hygiene Program is documented in Manual 4Q (Ref. 13) and serves to maintain employee exposures to chemical, physical and/or biological hazards within safe levels per applicable DOE and OSHA standards. The exposures to carcinogenic material are maintained ALARA per DOE Order 440.1A. Manual 4Q (Ref. 13) contains procedures for specific industrial hygiene hazards. Most of these procedures/programs apply to DWPF and are implemented through design, procedures, training, reviews, surveys, postings and use of personnel protective clothing.

Special industrial hygiene programs and methods of implementation at DWPF are described in the following subsections.

8.2.2.1 ALARA for Chemical and Hazardous Material

The SRS Industrial Hygiene policy, as discussed in Manual 4Q (Ref. 13), is to maintain each employee's personal work environment at a safe level of exposure from chemical, physical, and biological agents. Carcinogen exposures are maintained ALARA.

8.2.2.2 Carcinogen Control Program

Carcinogen exposure is controlled in accordance with Manual 4Q (Ref. 13). Any newly introduced raw material, support chemical or isolatable intermediate that poses a potential carcinogenic hazard requires documentation in accordance with the carcinogen control program.

8.2.2.3 Hazard Communication Program

A SRS Hazard Communication Program has been established and is contained in Manual 13B (Ref. 23). The purpose of this program is to ensure that hazards associated with chemicals are evaluated, hazard information is communicated, and training is provided to affected personnel. Other provisions of the HAZCOM programs (such as labeling and MSDS) are enforced through postings, procedures, audits and surveillance conducted within DWPF. The hazards associated with non-routine tasks are covered by special written job plans, procedures, or work clearance permits. Work groups assigned to non-routine tasks coordinate their efforts with the Industrial Hygiene group in accordance with Manual 4Q (Ref. 13).

8.2.2.4 Hazard Evaluation Program

The Hazard Evaluation Program is described in Section 8.2.4.
8.2.2.5 **Physical, Chemical, and Biohazards Control Programs**

Programs for controlling specific physical, chemical and biological hazards are contained in the 4Q Manual (Ref. 13). Some of the hazards and their controls at DWPF are described here. Changes or upgrades to hazard classifications are identified through the Hazard Evaluation process. These changes or upgrades are captured and appropriate responses are instituted.

**PHYSICAL HAZARDS**

**Noise**

Routine sound surveys are conducted at the request of Operations (e.g., to support process or equipment changes) by the IH section and as required by the hazard assessment program. The survey results may indicate a need to require engineering, administrative, or protective equipment. Manual 4Q (Ref. 13) describes the SRS Hearing Conservation Program and the requirements for performing sound level surveys and noise dosimetry studies. Hearing protection is required when noise level reaches or exceeds a predetermined value in any area. Areas within DWPF requiring hearing protection have signs posted at the entrances. Hearing tests are also given annually to employees exposed to a predetermined value in accordance with applicable regulatory standards. A sound level survey profile for each facility is maintained and updated as required.

**Thermal Stress**

The site's Thermal Stress Management Program, set forth in Manual 4Q (Ref. 13), has been implemented to guide DWPF personnel in managing potential heat stress conditions.

**Compressed Gas**

There are several types of gases used in the DWPF. Portable cylinders containing compressed and liquefied gases are handled, stored, and used in accordance with the requirements of Manual 13B (Ref. 23). 8Q Manual (Ref. 14), requires isolation and tagging the system/components for physical energy hazards prior to performing any maintenance work.

**Ergonomics**

Ergonomics considerations are taken into account when reducing the potential for employees musculo-skeletal disorders. An Ergonomics Program is implemented at DWPF in accordance with the requirements of 8Q Manual (Ref. 14).

**CHEMICAL HAZARDS**

The DWPF process uses chemicals and produces byproduct chemicals that present safety and health concerns to the workers (i.e., toxicity, flammability, corrosiveness).

Chemical hazards are addressed and controlled in several programs. Chemicals introduced to DWPF require review under the chemical control program of Manual 13B (Ref. 23), including
review of Material Safety Data Sheets (MSDSs). Process chemicals at DWPF used during Cold Chemical Runs, Waste Qualification Runs, and during Radioactive Operation were included in Process Hazard Reviews (PHRs) under a Process Safety Management Program (Ref. 16). PHRs were completed prior to receiving the applicable chemical at DWPF.

The transfer of process chemicals within any system is done under procedural direction, and IH reviews such procedures. Maintenance and repair activities, as well as inspections and other functions are conducted under Work Control Program. Work packages applicable to systems identified by IH require routing of such packages for IH review/concurrence. Exposure monitoring data assessments performed by IH are examined for procedural impact, and procedure revisions to upgrade/downgrade protection equipment and/or administrative controls are requested by IH as necessary. Collectively, these programs minimize chemical exposures through the proper hierarchy of industrial hygiene controls.

Asbestos Control Program

Asbestos used within DWPF is in the form of asbestos gaskets or contained within floor tiles. Floor tile assessment is conducted whenever a work package for flooring repair and/or carpet renovation is developed. An Asbestos Control Program is implemented at DWPF in accordance with 3Q (Ref. 12).

BIOHAZARDS

DWPF implements the Biohazards Management Program per Manual 4Q (Ref. 13), which provides the guidelines for preventing the occurrence of work-related injury or illness attributed to biohazardous materials transmitted in the workplace by ingestion, accidental injection, inhalation, or skin absorption from potential biological sources.

8.2.3 IDENTIFICATION OF HEALTH HAZARDS

The primary responsibility for the identification of health hazards lies with the immediate supervisor. A variety of activities have been instituted to identify and monitor conditions or practices that could be hazardous to employee health. The supervisors are responsible for bringing potential hazards to the attention of IH. Industrial Hygiene has the responsibility of assessing and communicating identified hazards to the supervisors for corrective action.

Potential occupational health hazards at the DWPF are identified by IH through a combination of surveillance activities (as defined in Section 8.2.4, Hazards Evaluation), the application of knowledge gained by years of operating experience, and application of the following specific activities that are described in Manual 4Q (Ref. 13), and Manual 8Q (Ref. 14):

- Material Safety Data Sheet (MSDS) reviews for new procurements by Chemical Commodity Management Center
- Container Labeling
- Industrial Hygiene Surveys including chemical and noise monitoring
8.2.4 HAZARDS EVALUATION

8.2.4.1 Categorized Industrial Hygiene Hazards

As described in Sections 8.2.2 and 8.2.3, a combination of activities is applied in DWPF to achieve the recognition, evaluation, and control of occupational health hazards. Manual 4Q (Ref. 13) establishes the sequence of health hazard assessment conducted at DWPF. This manual also identifies the process by which evaluations are continually updated to assure exposures are kept within safe limits. This includes a hazard assessment and control record, which is revised as new data (previous sampling results, process changes information, etc.,) is added. From these activities and published DOE and SRS guidelines, information is obtained which enables professional judgments to be developed regarding the degree of hazards and the controls necessary to reduce exposures to acceptable levels. Occupational Exposure Limits (OEL) are provided for occupational exposures to toxic substances in the applicable DOE Orders and DOE-prescribed Occupational Safety and Health (OSH) standards identified in Manual 4Q (Ref. 13). New activities and changes to existing activities for exposure potential are screened using the screening criteria in the Industrial Hygiene Screening Guide in Manual 4Q (Ref. 13). If the screen identifies potential hazards, the IH evaluates and analyses the potential hazards using accepted Industrial Hygiene practices and identifies controls in accordance with Manual 4Q (Ref. 13).

8.2.4.2 Uncategorized Industrial Hygiene Hazards

Chemicals for which no occupational exposure limits exist are evaluated to determine if they are hazardous. If a chemical is determined to be hazardous, those hazards are identified and evaluated on case-by-case basis.

8.2.5 EXPOSURE CONTROL MEASURES

The exposure control objective of the Industrial Hygiene program is to control each employee's exposure to nonradioactive toxic substances in routine situations to ensure that exposures are within the prescribed limits. Occupational Exposure Limits (OELs) and Administrative Control Limits (ACLs) are established in accordance with Manual 4Q (Ref. 13). The ACLs are usually lower than the OELs and are based on the baseline walkthroughs and historical data at DWPF. The ACLs are intended to be used as a decision point whether monitoring/controls are necessary to determine compliance and therefore ensures that exposures are within the OELs.

The Industrial Hygiene section assists DWPF in establishing controls such that each employee's work area is at a safe level of exposure to chemical, physical, and biological agents. The carcinogen exposures are maintained ALARA. To accomplish this, a hierarchy of controls is employed, which includes:

- Central Safety Committee and Subcommittee Activities
- Interorganizational Communications
- Review of Proposed Activities
- Substitution or elimination of the toxic substance
- Engineering controls such as dilution or local exhaust ventilation to reduce contamination to acceptable levels
- Administrative controls that typically reduce exposure durations
- Personal protective equipment that allows employees to work safely with toxic materials

These controls are identified in procedures and work packages. These control measures are augmented by an effective employee training and employee communication program.

8.2.5.1 Industrial Hygiene Instruments

Industrial Hygiene instruments at DWPF are selected from the available site resources. Site Industrial Hygiene Instruments, Manual 4Q1.2 (Ref. 24) provides the list, details of selection, use, limitations, maintenance, and calibration of portable instruments used by IH. These instruments are selected based on their applicability to the hazards being assessed and their demonstrated functionality.

8.2.5.2 Installed Sampling and Monitoring Equipment

Normal operations within DWPF do not directly expose personnel to facility-specific industrial hygiene hazards beyond those, which could be experienced during certain equipment repairs or maintenance activities. Chemical hazards associated with DWPF occur only if the chemical escapes the confines of the intended vessels and piping. Chapter 7 of the FSAR describes the monitoring and controls of gaseous and liquid effluents from DWPF. Chapter 11 of the FSAR describes various controls required for the safe operation of DWPF.

SRS Environmental Monitoring Plan, Manual 3Q1-2 (Ref. 11), describes various environmental monitoring locations and frequencies of samples performed sitewide.

8.2.5.3 Respiratory Protection Program

It is SRS's policy to protect employees from exposure to atmospheric contaminants (radioactive and non-radioactive) by using facilities and equipment with safeguards incorporated into their design. Engineering controls are the preferred method to protect employees from exposure to airborne contaminants, both radioactive and nonradioactive, within the workplace. Personal protective equipment is the method of last resort. Personal protective equipment such as respirators are only used under the following conditions:

- During the time period necessary to install engineering controls, evaluate controls, or repair controls
- In work situations in which engineering and administrative controls are not feasible or are insufficient to reduce exposure to acceptable levels
- In emergencies
The selection, use, control, inspection, maintenance, training, fit test and medical examinations required for use of respirators is detailed in Manual 4Q (Ref. 13). A breathing air system is installed at DWPF. Chapter 5 of the FSAR provides the details of this system.

8.2.6 MEDICAL MONITORING

The Medical Department at SRS plays a major role in the health maintenance of employees. Manual 4Q (Ref. 13) describes the health (medical) surveillance program that establishes the goal of protecting workers from occupational disease and harm. This program is designed to identify, at the earliest opportunity, trends or exposures affecting worker's health in the workplace and track physiological changes to workers exposed to occupational hazards.

8.2.7 RECORD KEEPING REQUIREMENTS

Industrial hygiene records, including the monitoring data obtained from surveys for chemical and physical agents, are summarized and survey reports are generated and submitted to management in the department surveyed. These records are maintained and dispositioned in accordance with the requirements of Manual 1B (Ref. 15), Procedure MRP 3.31 Records Management. Copies of surveys are retained by the Industrial Hygiene group.

Medical records are maintained by the Medical Department. Employee medical information and data are protected to ensure confidentiality. Employees and/or designated employee representatives may, upon request, view or copy any relevant medical or exposure data.
8.3 INDUSTRIAL SAFETY PROGRAM

8.3.1 ORGANIZATIONAL AND POLICY CONSIDERATIONS

8.3.1.1 Industrial Safety Organization

Within the DWPF, industrial safety involves the detection, mitigation, management, and prevention of workplace hazards to protect against accidental death, injury, property damage, or interruption of production. At SRS, the programmatic functions of the industrial safety program are administered by the Industrial Safety organization and the implementation functions are incorporated within the facility's line management, which has ultimate safety responsibility. Advisory responsibility is vested in several committees.

The Safety Program, which includes the safety requirements, procedures and responsibilities to implement these requirements, is established in Manual 8Q, Employee Safety Manual (Ref. 14). This program complies with prescribed DOE orders, OSHA guidelines, and ANSI standards as stated in the S/RIDs (Ref. 25) and 8Q Manual (Ref. 14).

Industrial Safety staff personnel assigned to the DWPF Project performs area inspections, equipment inspections, procedure reviews, and safety appraisals. They also act as consultants to operating personnel on questions concerning safety or safety design.

Ultimate responsibility for safety is, however, a line management responsibility. Management, which includes all levels from M&O and LW Presidents through the first-line supervisor, is responsible for safety. Each employee also shares in the responsibility for working in a safe manner and obeying safety rules stated in the Safety Manual 8Q (Ref. 14).

8.3.1.2 Industrial Safety Staff Qualifications

The Industrial Safety staff performs advisory function for the site. The Industrial Safety and Health Department is staffed by professional safety and process engineers. The Industrial Safety staff must stay current of emerging safety technologies as well as a working knowledge of the applicable safety requirements from OSHA, ANSI, NFPA, DOE Orders and SRS Manuals.

8.3.1.3 Industrial Safety Policy and Principles

It is an SRS policy that safety and protection of employees and the public is the first priority, and that work will cease before it is done unsafely. Safety excellence is a primary concern that is embodied in the principles stated in the Safety Manual 8Q (Ref. 14).

These principles are translated into administrative procedures and controls.
ADMINISTRATIVE PROCEDURES/CONTROLS

Reviews

At DWPF, a formal administrative control system ensures that basic and important decisions affecting safety or operability are adequately reviewed. Qualified operators who have received rigorous training in operating procedures and safety systems carry out the operating processes according to detailed written procedures. Manuals 2S, Conduct of Operations (Ref. 18), and E7, Conduct of Engineering and Technical Support (Ref. 22), require DWPF Engineering to review operating and maintenance procedures, design changes, and modifications for safety. Procedures and work control packages requiring specific safety considerations are also reviewed and concurred by the Safety Engineers assigned to DWPF.

Protective Equipment

Injury potential is reduced by the use of a variety of protective equipment. The type of protective equipment required for each task is defined in a procedure, job hazard analysis, or work package and is determined before work is started. Additionally, signs are posted in various areas in DWPF as required per Manuals 8Q (Ref. 14) and 4Q (Ref. 13) stating the protective equipment required to enter that area.

Training

DWPF management assumes primary responsibility for providing a safe work environment for each assigned employee. Management has the responsibility of ensuring that each employee has received adequate safety training before being allowed to perform a job. Departments are responsible for instructing their employees in all applicable plant policies, rules, and procedures and for conducting routine safety meetings to inform employees and encourage employee participation in all safety activities. Non-company personnel receive a safety orientation and must follow acceptable safety practices as a prerequisite for working onsite.

REPORTING AND RECORDING OCCUPATIONAL INJURIES/ILLNESSES OR NEAR MISSES

Occupational injuries/illnesses and near misses are reported, investigated, responded, and recorded in accordance with the requirements of the Safety Manual 8Q (Ref. 14). This manual also states the responsibilities of the employees and other personnel involved in the reporting, investigation, responding, and recording of occupational injuries/illnesses and near misses.
OTHER ADMINISTRATIVE PROGRAMS

Annual Safety Program

An annual Safety Program is communicated to each employee. The program provides general guidelines for development and implementation of departmental or area safety programs. Program safety topics include on-the-job and off-the-job safety.

Safety Manual

Manual 8Q (Ref. 14) is a reference of the basic safety policies and practices of the SRS site and is intended to be a broad guide to minimum safety requirements. The Manual is augmented by detailed rules and procedures developed by departments and by facility constraints.

Reporting Unsafe Practices or Conditions

The actions and practices which deviate from a prescribed safety procedure or generally recognized safe method, which may result in accident or injury, are considered unsafe practices. Any physical or mechanical hazard that could contribute to personal injury or illness to employees while performing their duties is considered an unsafe condition. Each employee has an individual responsibility to recognize and identify unsafe practices and conditions, and to correct them when possible. Unsafe practices are addressed in monthly safety meetings to encourage safe work habits. Unsafe conditions are reported, recorded and handled in accordance with the requirements of the Safety Manual 8Q (Ref. 14).

Safety Suggestion Program

The SRS Safety Suggestion Program provides encouragement and a convenient channel for employees to submit their ideas to supervision for improvements in safety, industrial hygiene, radiological control, radiation dose reduction, etc. Employees, whose suggestions are adopted, are recognized.

Audits, Appraisals, Evaluations, and Assessments

At DWPF, routine inspections of work areas are performed by management, area safety engineers, safety and housekeeping walkthrough teams, and observers. These inspections provide a means of detecting and correcting at-risk behaviors, unsafe conditions, safety rule violations, housekeeping items, fire hazards, and industrial hygiene concerns. In addition, departmental housekeeping audits, OSHA compliance audits, staff audits, formal and informal assessments, and area surveys are conducted on a regular, periodic basis. Manual 8Q (Ref. 14) establishes the minimum requirements and provides guidance for the conduct of safety and housekeeping audits and the subsequent documentation, distribution, and follow-up of noted deficiencies.
Hazard Analysis Program

The Safety Manual 8Q (Ref. 14) provides the methodology and requirements for identifying work place hazards and controls and for authorizing work using the a hazard analysis program to analyze tasks, new procedures, or procedure changes.

Safety Inspections and Inspection Labeling

Routine safety inspections are conducted for portable and semi-portable power tools and equipment. If repairs are needed to make equipment safe, but cannot be made immediately, the equipment is identified with a "Danger - Unsafe Condition" tag as required by 8Q Manual (Ref. 14). The user is responsible for visually inspecting and determining that equipment and tools are safe before each use.

Danger, Caution and Warning Tags

At DWPF, various tags are used to warn or control the hazards. These tags are installed and controlled in accordance with Manual 8Q (Ref. 14).

Barricades

Employee Safety Manual, Manual 8Q (Ref. 14) provides the details of various types of barricades, their use, setting up, removal, components, and responsibilities.

Confined Space Entry Program

SRS Confined Entry Program provides requirements for safe entry into Confined Spaces. This program is implemented by training, posting signs, procedures, Confined Space Entry Permit, and Work Clearance Permits. Manual 8Q (Ref. 14) provides the details of this program.

Process Safety Management (PSM) Program

The PSM program was constructed around the Process Hazards Review (PHR), which was a systematic review of processes that had the potential to result in significant accidents as defined by a set of accident criteria, in order to eliminate injuries and minimize property damage resulting from process-related hazards. The SRS Process Safety Management Manual, WSRC-IM-90-135 (Ref. 16) described the process by which PHRs were prepared, reviewed, approved, and issued. This program has been replaced by Consolidated Hazards Analysis Process (CHAP) program described in Chapter 10.

Interface/Liaison Activity

Environment, Safety and Health Services reviews major projects for compliance with DOE, Occupational Safety and Health Administration (OSHA), and National Fire Protection Association (NFPA) codes, standards and regulations. The reviews begin during the design phase and are continued until the project is completed. Any deviation found during a review is documented and addressed in accordance with the approved procedures.
8.3.2 IDENTIFICATION OF HAZARDS

This section describes the program elements, procedures, and documentation used to identify and mitigate industrial hazards (8.3.2.1) and process hazards (8.3.2.2) associated with operation of the DWPF.

8.3.2.1 Industrial Hazards

Protection against industrial hazards at DWPF relies on the rigorous application of standard industrial safety practices. In addition, hazards specific to DWPF are formally and systematically identified, assessed, and documented by various program elements discussed in Section 8.3.1.

8.3.2.2 Process Hazards

The process hazards associated with DWPF are systematically identified, assessed, and evaluated in various hazards analyses described in the Chapter 9.0 of the FSAR.

8.3.3 CONTROL AND MITIGATION OF HAZARDS

8.3.3.1 Industrial Hazards

Control and mitigation of industrial hazards have been initially established by the design of DWPF, followed by written procedures, training, controls, and continuous review of the safety program. The specific program elements, operating procedures, and documents that establish this control and mitigation are described in Section 8.3.1.

8.3.3.2 Process Hazards

Chapter 4 and 9 of the FSAR identify applicable set of prevention, detection and mitigation features for the hazards associated with DWPF process.
8.4 FIRE SAFETY PROGRAM

The Fire Protection Program Manual 2Q (Ref. 19), has been established to meet the Department of Energy (DOE) objectives to ensure that:

- No threats to the public health or welfare will result from a fire
- There are no undue hazards to site personnel from a fire
- Vital DOE programs will not suffer unacceptable delays as a result of fire
- Property damage from a fire will be held to manageable levels

The Savannah River Remediation Fire Protection Program Plan, F-PRP-G-00001, (Ref. 31), has been established in accordance with the Fire Protection Program Manual 2Q (Ref. 19) for DWPF to ensure that the objectives of the Fire Protection Program are met.

Fire protection criteria delineated in the DOE Orders, codes, standards and other documents identified in the SRR Standards/Requirements Identification Documents (S/RIDs) (Ref. 25), as applicable to DWPF, must be met or exceeded in the implementation of the DOE Fire Protection Program unless an exemption/equivalency either exists in DOE approved supporting documents or has been documented per approved procedure.

S-Area Fire Control Preplans have been established to identify and locate both active and passive fire protection features in each facility and to provide information necessary for proper emergency response in the event of fire. This is accomplished through various organizations, administrative programs and procedures for both passive and active systems. This plan is a comprehensive, integrated approach to minimize both the probability and consequences of fire. The plan is also used for facility and fire protection familiarization during site specific training drills and practices. The S-Area Fire Control Preplans are maintained in the SRS Fire Department Preplan Database.

DWPF fire protection design features and Fire Hazard Analysis (FHA) are described in Chapter 5 of the FSAR. The results of the FHAs were factored into the formulation of accident frequency and severity estimates during DWPF hazard assessments/evaluations as documented in Sections 9.3 and 9.4 of the FSAR.

8.4.1 FIRE PROTECTION ORGANIZATION AND RESPONSIBILITIES

Fire Protection Program Manual 2Q (Ref. 19) establishes responsibilities for the various organizations/departments for implementation of the Fire Protection Program. This includes management/personnel from facility (DWPF), engineering, support organizations, oversight organizations, and SRS Fire Protection.

DWPF management have overall responsibility for implementing the requirements of the Fire Protection Program as delineated in Procedure Manual 2Q within DWPF and ensuring personnel safety, protection of the environment, and property protection from the threat of fire.
DWPF engineering is the design authority for fire protection systems, structures and components and is responsible for reviewing and approving modifications to fire protection systems in accordance with Procedure Manuals E7 (Ref. 22). DWPF engineering ensures that applicable engineering criteria are met on new construction and major modifications. DWPF engineering reviews/approves DWPF FHAs and Fire Control Preplans.

8.4.2 ADMINISTRATIVE CONTROLS

DWPF management has established administrative controls (e.g., standing instructions and procedures) to ensure that conditions within the facilities are maintained consistent with the objectives of the fire protection program (Ref. 19). The following are the primary objectives of the administrative controls that have been implemented by management as part of the Fire Protection Plan at DWPF.

8.4.2.1 Control of Combustibles

The introduction of combustible materials into facilities at DWPF is carefully controlled. This program limits the introduction of additional combustible material to fire areas and initiates compensatory measures, where circumstances warrant, to ensure that accumulations do not present an increased risk to facilities or personnel.

8.4.2.2 Control of Ignition Sources

Restrictions on the use of ignition sources, such as cutting, welding and grinding activities in DWPF facilities are provided through a hot work permitting program.

8.4.2.3 Fire Watches/Fire Patrols

Fire watches/fire patrols are instituted as either required by procedure or whenever necessary to increase the level of fire protection within a designated area. Increases in the level of protection may be required during fire protection system impairment or when ongoing activities within the area raise the potential for fire. Personnel performing fire watch/fire patrol duties are trained. While on fire watch/fire patrol, personnel have no other responsibilities that might interfere with their fire watch/fire patrol duties.

8.4.2.4 Facility Inspections

Regular facility fire safety inspections are conducted in accordance with the requirements of 2Q manual (Ref. 19). At a minimum, these inspections include:

- Inspections of portable extinguishers
- Fire doors and fire barriers
- Storage of combustibles
- General housekeeping
- Exits and exit accesses
8.4.2.5 Testing and Surveillance

Regular fire protection system inspections and surveillance testing are conducted as required by S/RID Functional Area 12.0.

8.4.2.6 Fire Protection Impairments and Compensatory Actions

DWPF has implemented procedures to control impairments to fire protection systems. Impairments are controlled, documented, and compensatory actions are instituted in accordance with the requirements of 2Q manual (Ref. 19).

8.4.2.7 Fire Protection Deficiencies

Fire Protection deficiencies resulting from the fire protection activities specified in the 2Q Manual are documented and evaluated in accordance with the requirements of 2Q manual (Ref. 19).

8.4.2.8 Fire Prevention Inspection Program

Routine inspections of DWPF are conducted to confirm the adequacy of the following items related to fire protection:

- Control and handling of flammables and combustibles
- Control and handling of ignition sources
- Manual firefighting equipment
- Egress paths
- General housekeeping practices
- Proper position and general condition of fire and exit doors
- Access to building exterior including entrances
- Clear and unobstructed access to fire hydrants and post indicator valves
- Cutting and welding practices

The results of these inspections are documented in accordance with the 2Q Manual (Ref. 19).

8.4.2.9 Fire Safety Drills and Exercises

DWPF participates in fire drills conducted in conjunction with the Fire Department on a routine basis in accordance with the requirements of the Fire Protection Program. The Fire Department develops and maintains the frequency and criteria for determining the need for and evaluating the success of drills and exercises in accordance with the 2Q Manual (Ref. 19).
8.4.2.10 Fire Protection Program Reports and Recordkeeping

Fire Protection Program reports and records are prepared, transmitted and maintained in accordance with the requirements of the 2Q manual (Ref. 19).

8.4.3 TRAINING AND QUALIFICATIONS

8.4.3.1 General Employee Training & Consolidated Annual Training

Each SRS employee receives fire protection training through the Site General Employee Training (GET) & Consolidated Annual Training (CAT) programs described in Manual 4B, Training and Qualification Program (Ref. 20).

8.4.3.2 DWPF Operations Training

The DWPF facility provides training and qualification of DWPF shift personnel for fire alarm responses.

8.4.3.3 SRS Fire Department Training

Each firefighter in SRS Fire Department must be certified under an approved program.

8.4.4 FIRE EMERGENCY RESPONSE

8.4.4.1 SRS Fire Department

The SRS Fire Department firefighters are the primary fire fighting organization for the site. They respond with sufficient emergency equipment to ensure suppression of fires at DWPF. The Fire Department directs fire fighting activities at the fire scene with support from the Incident Scene Coordinator.

The SRS Fire Department maintains Fire Stations at strategic locations and the fire control preplans for DWPF, which provide necessary information in fighting a fire.

8.4.4.2 DWPF Fire Response

A fire in the DWPF requires response from area personnel. Designated fire support individuals must respond to suppress the fire in its incipient stage and/or provide support to SRS Fire Department. Personnel not assigned to fire support duties are notified of the fire and have been trained to evacuate as directed by the emergency evacuation procedures. The DWPF Shift Manager and staff maintain control and authority over plant operations within the area during the fire emergency.

8.4.4.3 Control Room Operator

On receipt of a fire alarm in the CCR or notification from the Emergency Duty Officer (EDO), the Control Room Operator initiates the area fire response procedure. The operator is
8.4.4 Incident Scene Coordinator

The Incident Scene Coordinator is the Operations Department representative in control of activities at the fire scene. The Incident Scene Coordinator is head of the Facility Support Team and establishes the initial Fire Scene Command Post and ensures that the Fire Department firefighters are properly directed to the fire scene. The Fire Department, with support from the Incident Scene Coordinator, directs the fire suppression efforts giving particular consideration to existing and potential abnormal plant conditions.

8.4.4.5 Facility Support Team

The Facility Support Team includes designated personnel on each shift from various groups within the DWPF area. They are required to respond to the fire scene to support plant operations and fire fighting activities as directed by the Incident Scene Coordinator.

8.4.4.6 Electrical and Instrumentation

Designated, on-shift Electrical and Instrumentation (E&I) personnel respond to the Fire Command Post for fires in the area. Under the direction of the Incident Scene Coordinator, the E & I personnel disconnect electrical power or perform any other electrical work necessary during the fire emergency as requested.

8.4.4.7 Radiological Control

If a fire is in the radiological area, or if Radiological Control personnel are needed at the scene, the DWPF Shift Manager (or designee) will notify Radiological Control. Designated, on-shift RC personnel respond to the Fire Command Post for fires that might involve a radiological or toxic material. Under direction of the Incident Scene Coordinator, Radiological Control personnel are responsible for establishing appropriate RBA and contamination control boundaries and providing guidance on protective clothing and the handling of hazardous materials.

8.4.4.8 General Personnel

Non-fire fighting personnel evacuate the fire area in accordance with area fire response procedures.
8.5 NUCLEAR CRITICALITY SAFETY PROGRAM

8.5.1 INTRODUCTION

This section provides an overview of the criticality safety program established for the DWPF. This overview includes a discussion of the nuclear criticality safety requirements, the criticality safety bases and criticality controls, the criticality safety organization, and the DWPF criticality safety training program.

8.5.2 REQUIREMENTS

The SRR Standards/Requirements Identification Documents (S/RIDs) (Ref. 25) state the codes, standards, and regulations governing the nuclear criticality safety at SRS.

8.5.3 CRITICALITY SAFETY BASES

The DWPF evaluates criticality concerns through Nuclear Criticality Safety Evaluations (NCSEs). The Nuclear Criticality Safety Analysis Summary Report (NCSASR) (Ref. 27) summarizes the approved 512-S and DWPF NCSEs and captures all the nuclear criticality safety requirements from the NCSEs. The following sludge and salt processing modes have been evaluated:

- Processing of Tank Farm sludge (including sludge with non-tank farm plutonium) through the DWPF, and
- Processing of Tank Farm salt solution with an equivalent $^{235}$U[$^{235}$U(eq_sol)] enrichment less than or equal to 3.0 wt% and soluble U and Pu concentrations less than or equal to 50 mg/L and 0.3 mg/L, respectively, and then blending the salt solution with the DWPF sludge in the SRAT

The NCSASR (Ref. 27) summarizes the identified scenarios and barriers/controls that address criticality in the 512-S and DWPF NCSEs. These NCSEs demonstrate that no credible criticality scenarios exist for processing sludge only as well as processing MST laden salt solution through 512-S, blending the concentrated MST/sludge solids and MCU Strip Effluent with sludge in the SRAT, and processing the SRAT contents through the Melter. Furthermore, a criticality event due to addition of the 512-S oxalic acid to the SRAT is deemed incredible. An unmitigated credible criticality event does exist as a result of Filter-Only (no-MST) operations in 512-S. This event is prevented based on the controls as listed in Section 8.5.4. The baseline NCSEs focus on the fate of iron and manganese (neutron poisons) and fissile material in the 512-S / DWPF process under normal and credible abnormal operating conditions.

8.5.4 CRITICALITY CONTROLS

The NCSASR summarizes the conclusions of the NCSEs that, with the exception of Filter-Only (no-MST) operations at 512-S, no credible criticality scenarios exist for processing sludge and salt streams at DWPF due to the low concentration of fissile material, the presence of neutron poisons and the low uranium enrichment. The WAC is considered an initial condition safety
control which supports the assumptions made in the NCSEs. Additional criticality safety controls/barriers are identified to prevent an inadvertent criticality in 512-S and DWPF (i.e., design features, programmatic requirements and administrative limits and requirements).

8.5.4.1 Design Features

The following DWPF tanks have design features that are identified for nuclear criticality safety in the NCSASR (Ref. 27): SRAT, SME, SMECT, SEFT, PRFT, REDC soak tank, RCT, DWTT, PPT, LWPT, and LWHT. All design features identified are passive. All future modifications affecting these design features shall be evaluated for the effect on criticality safety.

8.5.4.2 Programmatic Requirements

The following programs are credited to help demonstrate that a criticality accident is either not credible or prevented in DWPF (Ref. 27).

1. CST TSR Controls on Transfers to DWPF

   The Tank Farm Technical Safety Requirements have a number of criteria specified to control the transfer of material from CST into DWPF as identified in Section 11.7.2.2.

2. DWPF Transfer Control Program

   The DWPF Transfer Control Program governs radioactive waste transfers. The program includes the following attributes:

   a. Provide means to monitor transfer and stop transfers when material is unaccounted for.
   b. Establish and maintain continuous communication within the sending and receiving facilities during transfers (this attribute is only applicable to transfers between DWPF and CST).

3. DWPF Configuration Control Program

   The DWPF Configuration Control Program includes the following attributes:

   a. Identifies and documents the technical baseline of structures, systems, and components, and computer software;
   b. Ensures that changes to the technical baseline are properly developed, assessed, approved, issued, and implemented; and
   c. Maintains a system for recording, controlling, and indicating the status of technical baseline documentation on a current basis.
   d. Determine and implement testing/inspection requirements to ensure temporary modifications used as credited SC or SS SSCs meet Chapter 4 requirements.
8.5.4.3 **Administrative Limits and Requirements**

The following Administrative Limits and Requirements are listed in the NCSASR (Ref. 27).

1. Prior to introducing filter cleaning oxalic acid in the LWPT, sufficient sodium hydroxide to neutralize the oxalic acid shall be added to the LWPT.

2. The Certificate of Analysis (COA) accompanying the oxalic acid tanker truck shipment shall be reviewed to ensure that the molarity of the oxalic acid is \( \leq 0.6 \) M.

The use of oxalic acid (or any other acid that preferentially separates iron from plutonium) shall be prohibited in the DWPF and DWPF support facilities process areas. Exceptions to this requirement are:

- Oxalic acid (\( \leq 0.6 \) M) is used in cleaning the 512-S crossflow filter and the secondary filter which are physically separated from the DWPF and the DWPF support facilities.

  - Spilled oxalic acid from the 512-S Oxalic Acid Storage Tank diked area may be collected and neutralized at 980-S.

  - Oxalic acid is delivered to the 512-S facility via a tanker truck and stored in the 512-S facility.

- Samples from the oxalic acid tank in 512-S may be taken and sent to the 221-S DWPF analytical laboratory or the DWPF outside modular laboratory to verify the molarity of the oxalic acid. The oxalic acid samples and standards in the 221-S DWPF analytical laboratory will be disposed of in a drain pipe that is connected to the RCT, and the oxalic acid samples and standards in the DWPF outside modular laboratory will be disposed via drains to an S-Area outfall.

  - The combined volume of the oxalic acid samples and standards does not exceed 500 ml if the oxalic acid is disposed of to the RCT. The combined volume of oxalic acid samples and standards is not a criticality safety issue if the disposal path is the drains to an S-Area outfall.

3. Prior to performing oxalic acid transfer to LWHT, valves HV6231 (DCS Indication: HIS6231), HV6244 (DCS Indication: HIS6244) and FV6235 (DCS Indication: HIS6235A) shall be closed and verified to be closed by a second person per written procedures. This may be performed by visual inspection or by DCS Indication.

4. During an oxalic acid transfer to LWHT, the LWHT level shall be monitored. If there is no increase in the LWHT level within three minutes from the start of the transfer, the oxalic acid transfer shall be stopped until an investigation determines why the level did not increase.

5. During an oxalic acid transfer to LWHT, the LWPT level shall be monitored. If a change in the LWPT level is noticed, the oxalic acid transfer to LWHT shall be stopped until an investigation determines why the LWPT level increased.

7. The DWPF WAC program shall ensure the following requirements for maintaining the sludge subcritical during DWPF processing are met:

  - The \( {^{240}}\)Pu concentration shall exceed the \( {^{241}}\)Pu concentration.
The equivalent uranium enrichment in the sludge shall be:
- \( \leq 0.93 \text{ wt} \% \text{ } ^{235}\text{U} \) (eq), or
- \( \leq 5.0 \text{ wt}\% \text{ } ^{235}\text{U} \) (eq) with a Mn: \( ^{235}\text{U} \) (eq) mass ratio of \( \geq 70:1 \)

The overall Fe: \( ^{239}\text{Pu} \) (eq) mass ratio shall be \( \geq 160:1 \) and only Fe from the Tank Farm material shall be included in the calculation of the ratio.

The \( ^{239}\text{Pu} \) (eq) mass in the SRAT shall be:
- \( \leq 6,195 \text{ g} \), if non-Tank Farm Pu is included in the sludge batch.
  Note: Calculations show that 6,195 grams of \( ^{239}\text{Pu} \) (corresponding to 0.59 g Pu/gallon of sludge) in 10,500 gallons of sludge in the SRAT is subcritical at any moderation (i.e., any degree of settling and densification) as long as the Fe: \( ^{239}\text{Pu} \) (eq) mass ratio is \( \geq 80:1 \) in the overall SRAT contents.
  - No Pu(eq) mass limit, if only Tank Farm Pu is included in the sludge batch.

8. Prior to processing each sludge batch beyond Sludge Batch 3, an evaluation shall be performed and documented via the DWPF WAC program to demonstrate that the compositions of that sludge batch comply with the requirements as shown in item 7 above.

9. The DWPF WAC program shall ensure the following requirements for the salt solution batch are met (these salt solution characteristics support the subcriticality of processing the salt solution in DWPF facilities):
- The soluble uranium concentration in salt solution is less than or equal to 50 mg/L.
- The soluble plutonium concentration in salt solution is less than or equal to 0.3 mg/L.
- The \( ^{235}\text{U} \) (eq_sol) enrichment in salt solution is less than or equal to 3.0 wt\%.

10. Prior to transitioning to Filter-Only operations at 512-S the LWPT shall be de-inventoried below 8,490 grams of MST.

The NCSASR (Ref. 27) requires Items 7, 9, and 10 to be elevated to a Specific Administrative Control (SAC) in Reference 28.

8.5.5 CRITICALITY SAFETY ORGANIZATION

DWPF Engineering is responsible for criticality safety at the DWPF and will maintain an interface with other organizations to obtain criticality safety engineering support and review as necessary. Programmatic responsibilities and interfaces are defined in Reference 26. As part of the DWPF design authority technical review process, design changes that could impact the criticality safety bases are reviewed by DWPF Engineering personnel.
8.5.6 CRITICALITY SAFETY TRAINING

Based on the Criticality Safety Bases (Section 8.5.3) and Criticality Controls (Section 8.5.4), a detailed Criticality Safety Training program is not required for DWPF personnel. A basic review of the 512-S and DWPF NCSEs is provided to the DWPF technical staff personnel as part of their DWPF design authority technical reviewer training.

8.5.7 CRITICALITY INSTRUMENTATION

No criticality alarm and/or detection systems are required since criticality is either not credible or prevented at 512-S and DWPF.
8.6 REFERENCES

4. Deleted.
5. Deleted.
6. Deleted.
7. Deleted.
8. Deleted.
11. SRS Environmental Monitoring Plan. 3Q1-2.
17. Deleted.


