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1	1	Design Mgr. C. S. Haller	[signature] for CSH 9/4/2000	X3-78	1	1/2	Other J. E. Kurtz	[signature] 9/11/00	X3-68
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1	1	QA B. K. Ramsgate	[signature] 9/6/00	X3-78					

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Cold Vacuum Drying Facility Sampling and Analysis Plan

Project No: W-441 Division: SNF

John J. Irwin
Fluor Hanford, Inc.

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COLD VACUUM DRYING FACILITY SAMPLING AND ANALYSIS PLAN

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List of Acronyms

ALARA	As Low As Reasonably Achievable
CSB	Canister Storage Building
CVD	Cold Vacuum Drying
DF	Decontamination Factor
ETF	Effluent Treatment Facility (200E Area)
FME	Foreign Material Exclusion
HIC	High Integrity Container
HVAC	Heating, Ventilating, and Air Conditioning
IWTS	Integrated Water Treatment System
IXM	Ion Exchange Modules
LLW	Low Level Waste
MCO	Multi-Canister Overpack
MCS	Monitoring and Control System
PWC	Process Water Conditioning
PWS	Process Water Sampling
SARP	Safety Analysis Report for Packaging
SNF	Spent Nuclear Fuel
TW	Tempered Water
VPS	Vacuum Purge System

1.0 INTRODUCTION

The Cold Vacuum Drying (CVD) Facility provides the required process systems, supporting equipment, and facilities needed for the conditioning of spent nuclear fuel (SNF) from the Hanford K-Basins prior to storage at the Canister Storage Building (CSB). The process water conditioning (PWC) system collects and treats the selected liquid effluent streams generated by the CVD process. The PWC system uses ion exchange modules (IXMs) and filtration to remove radioactive ions and particulate from CVD effluent streams. Water treated by the PWC is collected in a 5000-gallon storage tank prior to shipment to an on-site facility for additional treatment and disposal.

The purpose of this sampling and analysis plan is to document the basis for achieving the following data quality objectives:

1. Measurement of the radionuclide content of the water transferred from the multi-canister overpack (MCO), vacuum purge system (VPS) condensate tank, MCO/Cask annulus and de-ionized water flushes to the PWC system receiver tanks.

2. Trending the radionuclide inventory of IXMs to assure that they do not exceed the limits prescribed in HNF-2760, Rev. 0-D, "Safety Analysis Report for Packaging (Onsite) Ion Exchange Modules," and HNF-EP-0063 Rev. 5, "Hanford Site Solid Waste Acceptance Criteria" for Category 3, non-TRU, low level waste (LLW).

3. Determining the radionuclide content of the PWC system bulk water storage tank to assure that it meets the limits set forth in HNF-3172, Rev. 0, "Hanford Site Liquid Waste Acceptance Criteria," to permit transfer and disposal at the Effluent Treatment Facility (ETF) located at the 200 East Area.

2.0 PROCESS DESCRIPTION

2.1 CVD Facility Process Overview

The CVD Facility receives MCOs that are loaded with SNF from the K West and K East fuel storage basin. The MCO is filled with de-ionized water from the effluent of the K West and K East Basin integrated water treatment system (IWTS). The annulus space between the MCO and the transportation cask is filled with de-ionized water from the K West and K East Basins leased ion exchange units.

In the initial step of the drying process, the PWC serves as a vacuum source and provides receiver tanks for the draining of the water in the MCO. During a subsequent step of the drying process, water vapor removed by the VPS and stored in the VPS condenser tank is transferred to the PWC receiver tanks. At the conclusion of the drying process, water from the tempered water (TW) system and the cask annulus are transferred to the PWC receiver tanks. Additional sources of water transferred to the PWC receiver tanks are de-ionized water used to flush piping and vessels and condensate from CVD Facility process bay re-circulation heating, ventilation and air conditioning (HVAC) systems.

Only the water transferred from the MCO during the initial water removal step is expected to have a significant concentration of radionuclides. The other sources are considered to be potentially contaminated.

2.2 PWC System Overview

The PWC system is located in the process water tank room of the CVD Facility. The major components of the system are two receiver tanks (PWC-TK-4032 and PWC-TK-4033), an ejector (PWC-EJR-4031), IXMs (PWC-IXM-4037 and PWC-IXM-4038), particulate filter (PWC-F-4042), automatic samplers (PWC-SMP-4039, PWC-SMP-4040, PWC-SMP-4041), a 5000-gallon water storage tank (PWC-TK-4001), pumps, piping and instrumentation. The CVD Facility PWC system is described in the system design description document, SNF-3082.

The IXMs provide the principal means of removing radioactive contaminants from CVD Facility process streams. The IXMs consists of six ion exchange columns , inlet manifold, vent lines and outlet flow control valves inside a concrete monolith. The IXM monolith provides shielding during operation and serves as a transportation package and high integrity container (HIC) for burial as LLW. There is one in-service IXM and one installed spare IXM located in the CVD Facility tank room. One CVD Facility IXM is in spares inventory.

Each of the six ion columns have a resin capacity of 3.5 cubic feet for a total capacity of 21 cubic feet for the IXM. The columns are loaded with a mixture of ion exchange resin designed to provide the highest possible decontamination factor (DF) for the radionuclides in the CVD Facility process streams. Each column is loaded with Purolite NRW-35[1], a nuclear grade mixed-bed resin in hydrogen/hydroxide form that removes all ionic species from the influent stream, but is also highly selective for cesium. Each column is capped with Purolite NRW-501P[1], a macroporous strong base anion resin in hydroxide form. This resin type is used to remove colloidal particulate, and transuranic isotopes present in the process stream as anion complexes.

There are four different modes of operation for the PWC system:

[1] Purolite NRW-35 and Purolite NRW-501P are trademarks of the Purolite Company, Bala Cynwid, Pennsylvania

Re-circulation Mode (Figure 2-1): In re-circulation mode, water is continuously recirculated by pumps from the PWC receiver tanks through an ejector and back to the receiver tanks. The vacuum created by the ejector is used to transfer water from various sources to the receiver tanks. The PWC is operated in this mode primarily during the processing of an MCO.

Ion Exchange Mode (Figure 2-2): In ion exchange mode, water is re-circulated from the receiver tank through an IXM to remove both radioactive and non-radioactive ions and colloidal particulate. The system is configured and controlled by the CVD Facility monitoring and control system (MCS) to provide a minimum of six volume exchanges of the receiver tank contents through the IXM.

Transfer to Storage Tank Mode Figure (2-3): After the initial ion exchange, the water is pumped through the IXM and a 5-micron cartridge filter to the 5000-gallon water storage tank. This mode will typically be entered following the processing of an MCO, or when the PWC receiver tanks are full.

Tank Re-circulation/Transfer to Tanker Mode Figure (2-4): In this mode, water in the bulk water storage tank is re-circulated to provide a homogenous sample for verification of tank contents. If needed, the contents of the bulk water storage tank can be re-circulated though the IXM and cartridge filter for further treatment. The water is then pumped from the bulk water storage tank to a tanker located in CVD Facility Process Bay 1. The tanker is transported to the ETF for further treatment and disposal.

The modes of operation for the PWC system are described in the CVD Facility Operations Manual, SNF-2356.

2.3 Process Water Sampling System

The process water sampling (PWS) system consists of three automatic samplers. The samplers are mounted directly to sections of PWC piping located upstream of the IXMs, cartridge filter and water storage tank, respectively. The samplers are designed to extract a representative sample (both liquid and particulate) of fixed volume (10 ml) from the process stream for every 30 gallons of water processed. The CVD Facility MCS uses process variables (the volume of water to be treated and the PWC mode of operation) to determine the timing and frequency of the samples taken. The samples are collected in 500-ml polyethylene sample bottles that are attached directly to the auto-samplers. The samplers are located on the west end of the PWC skid.

In Re-circulation Mode, sampler PWC-SMP-4039 collects the sample used to determine the radionuclide content of the water transferred to the PWC receiver tanks. This sample also serves as the IXM inlet sample. In Transfer to Storage Tank Mode, PWC-SMP-4040 is used to collect the ion exchange outlet and filter inlet sample; PWC-SMP-4041 is used to collect the filter outlet and bulk water storage tank inlet sample.

Figure 2-1 - PWC Flow Path During Re-Circulation Mode

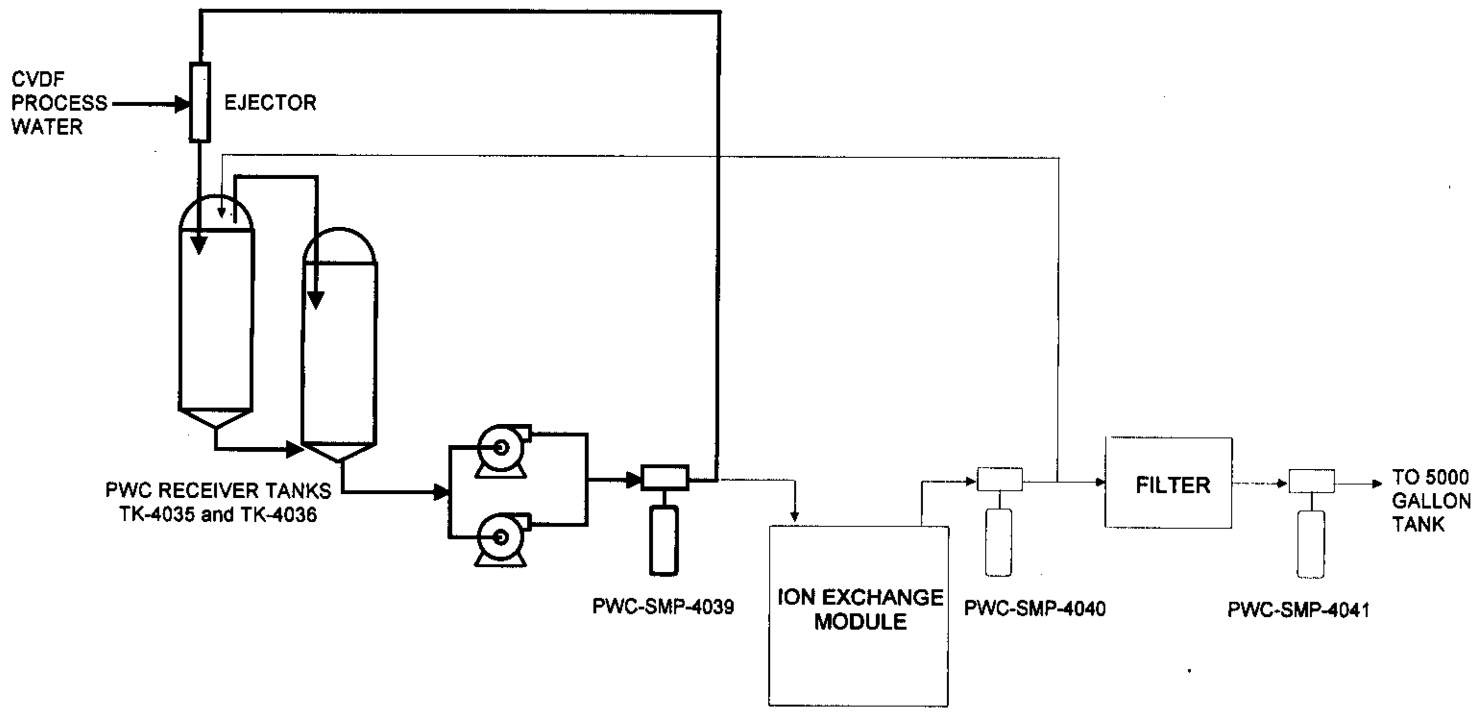


Figure 2-2 - PWC Flow Path During Ion Exchange Mode

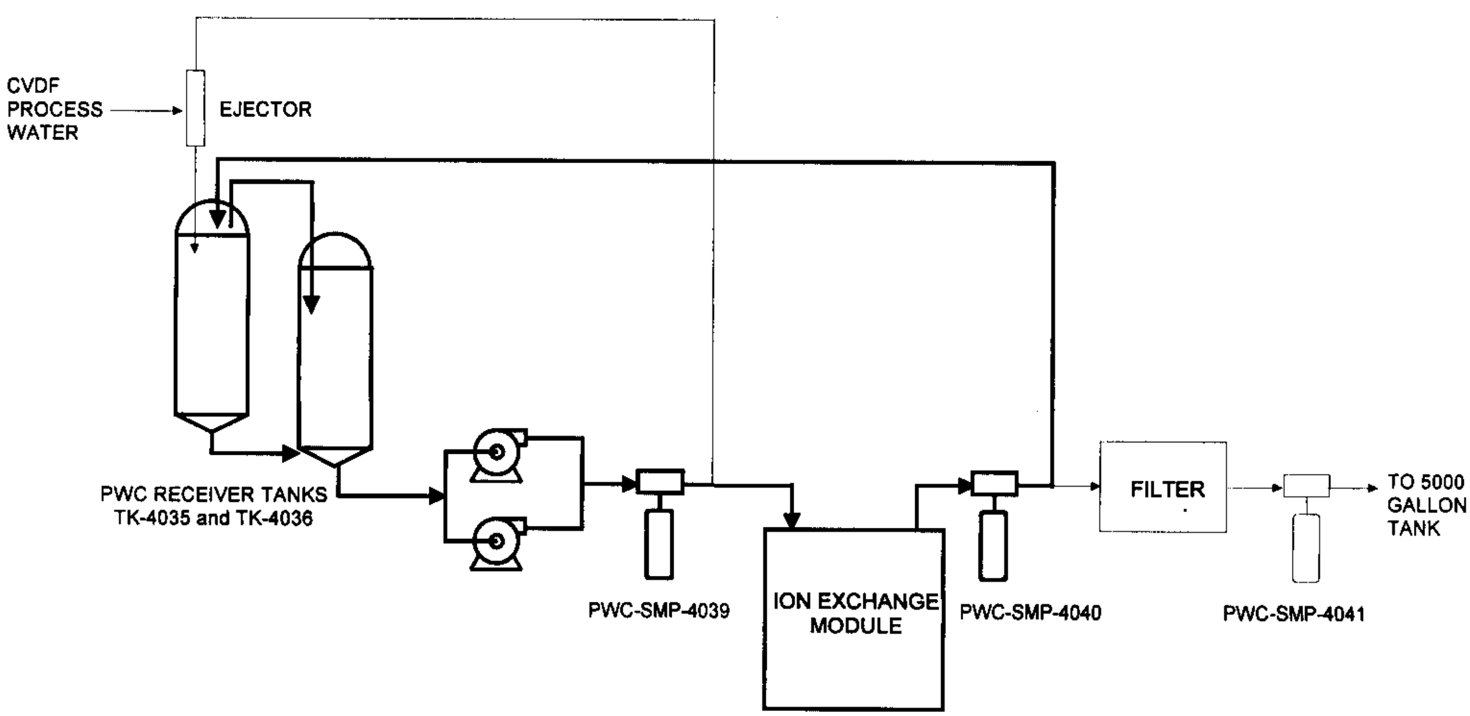


Figure 2-3 - PWC Flow Path During Transfer to Storage Tank

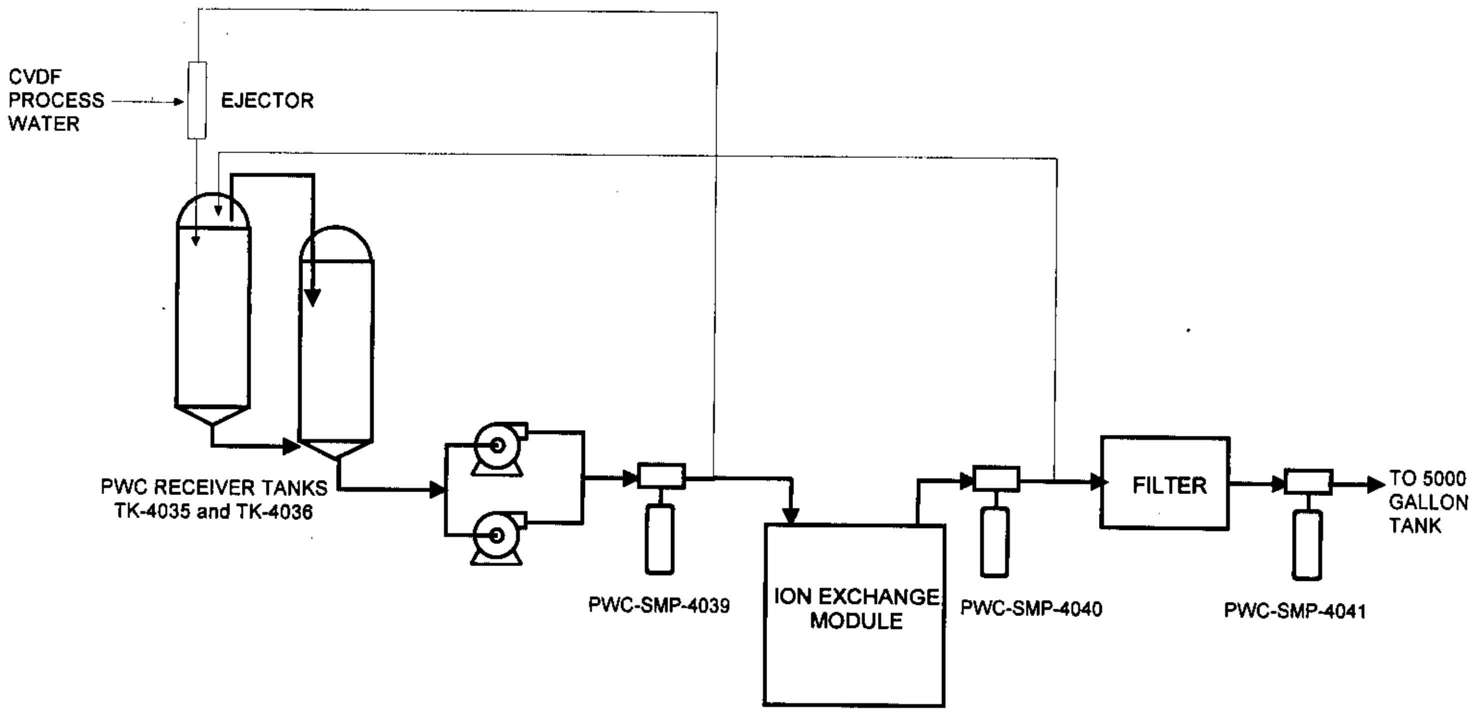
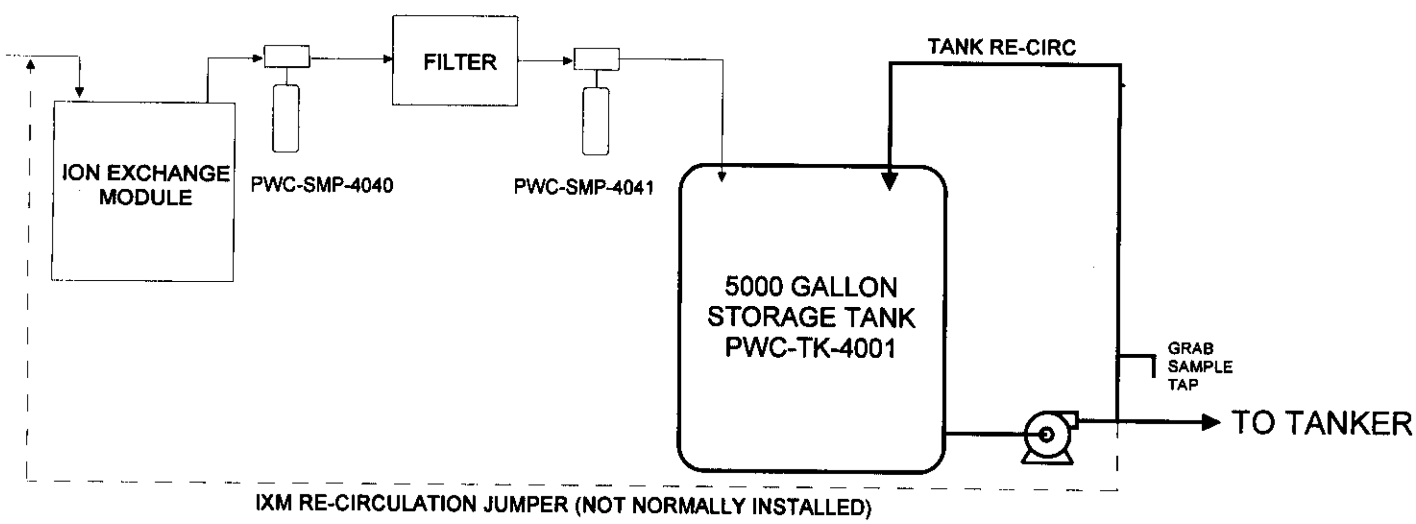


Figure 2-4 - PWC Flow Path During Transfer to Tanker



Prior to initiating bulk water transfer, a manual sample tap (PWC-V-012) on the outlet of the bulk water storage tank allows a grab sample to be collected for verification of tank radionuclide contents. Three additional sample/drain taps (PWC-V-009, PWC-V-013 and PWC-V-044) are available on the PWC skid to obtain grab samples if required.

2.4 Radio-Chemical Characteristics of the CVD Facility Process Water

A significant percentage of the SNF stored in the K Basins was damaged during discharge and subsequent handling. The unrestricted contact of the exposed uranium metal with the water in the MCO results in the release of radionuclides due to corrosion of the uranium. This corrosion releases Cs-137, Sr-90 and other radionuclides directly to the MCO water as soluble ions. The concentration of these radionuclides in the MCO water is a function of the surface area of exposed uranium metal, the temperature of the SNF and water and the time period over which the corrosion occurs. Thus, depending the conditions present, there will be considerable variation in the concentrations of Cs-137, Sr-90 and other soluble radionuclides in the MCO water. While the concentration may vary, the isotopic distribution of the soluble radionuclides remains unchanged.

Tritium is also released from the corrosion of the fuel and is carried over from the basins in the water initially placed in the MCO. Tritium inventory is not reported for spent IXMs because the amount of tritium retained in the residual water in ion exchange media is insignificant. However, Tritium concentrations are measured and reported for the water in the bulk water storage tank that will be shipped to the ETF.

The corrosion of the uranium metal also releases uranium, plutonium, americium and other largely insoluble radionuclides. Only a tiny fraction of these are initially released to the MCO water in a soluble form. The remainder will become a sludge consisting of insoluble oxides and hydroxides. The concentration of the soluble forms of these radionuclides in the water is due to a complex equilibrium that exists between the water and the sludge. While the concentration of these radionuclides will fluctuate depending on the carry over of particulate from the MCO to the PWC, the isotopic distribution remains constant.

The majority of the fuel stored in K Basins was discharged from the N Reactor between 1971 and 1987. Thus, most of the short-lived radionuclides in the fuel inventory have already decayed to the point that they are no longer detectable in the MCO water. The radionuclides that are present in the MCO water and which must be reported in waste characterization documents are the longer lived fission products, Cs-137 and Sr-90; the transuranic isotopes, Pu-239, Pu-240 and Am-241; and uranium.

2.5 Chemical and Physical Characteristics of CVD Facility Process Water

The CVD Facility process water consists entirely of de-ionized water containing trace radioactive contaminants that result from the corrosion of SNF contained within the MCO. The water initially added to the MCO at the K West Basin is cooling pool water that has been processed through garnet filters and IXMs. The water added to the MCO/Cask annulus at the K West Basin is non-contaminated service water that has been processed through filters and leased ion exchange tanks. An administrative program is in place at the K Basins to strictly control the water quality of the cooling pools.

The CVD Facility de-ionized water system consists of a charcoal filter, two mixed-bed ion exchange tanks in series and a 5-micron final filter. Thus, any water added to the MCO or used in processing an MCO at the CVD Facility is high quality de-ionized water. There are no hazardous materials used during the processing of an MCO. Strictly enforced foreign material exclusion (FME) requirements precludes the inadvertent addition of any hazardous material during normal operations and system maintenance.

3.0 CHARACTERIZATION METHODOLOGY

3.1 PWC Receiver Tanks and IXM Inlet

1. The PWC is configured to recycle water through the receiver tanks to assure a homogeneous mixing of the water is maintained.

2. The total volume of water in the receiver tanks (including heel) is recorded.

3. The MCS instructs sampler PWC-SMP-4039 to collect a 10-ml sample for each 30 gallons of water to be processed as a minimum. The MCS can be instructed to collect additional quantities if required.

4. The sample is sent to an on-site laboratory for radio-chemical analyses. Verification samples will be analyzed for:

   - Cs-137
   - Sr-90
   - Pu-239/240
   - Am-241
   - Uranium

   Routine samples will be analyzed for:

   - Cs-137
   - Total alpha

5. For verification samples, the quantity of radionuclides transferred from the MCO is calculated by multiplying the sample result for each radionuclide by the volume of water in the receiver tanks. For routine samples, conversion tables derived from isotopic ratios are used to determine the concentration of each radionuclide from Cs-137 and total alpha. These values are multiplied by the volume of water in the receiver tanks to obtain the quantity of radionuclides transferred from the MCO.

3.2 IXMs

1. The PWC is configured to recycle water through the IXM (approximately six receiver tank volumes) to remove radionuclides from the water.

2. The PWC is configured to transfer water through the IXM and cartridge filter to the 5000-gallon bulk water storage tank.

3. The total volume of water to be transferred (receiver tank volume – heel) is recorded.

4. The MCS instructs sampler PWC-SMP-4040 to collect a 10-ml sample for each 30 gallons of water to be transferred as a minimum. The MCS can be instructed to collect additional quantities if required. This is the IXM outlet sample.

5. The sample is sent to an on-site laboratory for radio-chemical analyses. Verification samples will be analyzed for:

   - Cs-137
   - Sr-90
   - Pu-239/240
   - Am-241
   - Total alpha
   - Total Uranium

   Routine samples will be analyzed for:

   - Cs-137
   - Total alpha

6. For verification samples, the quantity of radionuclides is calculated by multiplying the sample result for each radionuclide by the volume of water transferred to the bulk water storage tank. For routine samples, conversion tables derived from isotopic ratios are used to determine the concentration of each radionuclide from Cs-137 and total alpha. These values are multiplied by the volume of water transferred to the bulk water storage tank to obtain the quantity of radionuclides in the IXM outlet.

7. The radionuclide inventory accumulated by the IXM is calculated by mass balance (inlet-outlet). This data is summed over the service life of the IXM. The IXM will be removed from service when it reaches administrative limits provided in section 4.0.

3.3 PWC Water Storage Tank

1. The PWC is configured to transfer water through the IXM and cartridge filter to the 5000-gallon water storage tank.

2. The total volume of water to be transferred (receiver tank volume – heel) is recorded.

3. The MCS instructs sampler PWC-SMP-4041 to collect a 10-ml sample for each 30 gallons of water to be transferred. as a minimum. The MCS can be instructed to collect additional quantities if required. This is the tank inlet sample.

4. The sample is sent to an on-site laboratory for radio-chemical analyses. Verification samples will be analyzed for a variety of radionuclides including Cs-137, Sr-90, Pu-239/240, Am-241, tritium and uranium. Routine samples will be analyzed for Cs-137, tritium, total alpha and total beta.

5. For verification samples, the quantity of radionuclides is calculated by multiplying the sample result for each radionuclide by the volume of water transferred to the bulk water storage tank. For routine samples, conversion tables derived from isotopic ratios are used to determine the concentration of each radionuclide from Cs-137 and total alpha. These values are multiplied by the volume of water transferred to the bulk water storage tank.

6. The sample data for each transfer is summed to provide an estimate of the radionuclide content of the bulk water storage tank. This data will be used to determine if it will be necessary to process the contents of the bulk water storage tank through the PWC IXM and filter.

7. Prior to scheduling a shipment of water from the PWC bulk water storage tank to the ETF, a grab sample will be taken and analyzed to assure that the radionuclide concentration of the water does not exceed ETF acceptance criteria as defined in HNF-3172.

   Verification samples will be analyzed for:

   - Cs-137
   - Sr-90
   - Pu-239/240
   - Am-241
   - Tritium
   - Total alpha
   - Total beta
   - Uranium

Routine samples will be analyzed for:

- Cs-137
- Tritium
- Total alpha
- Total beta

4.0 ADMINISTRATIVE LIMITS FOR IXMS

Administrative limits for the radionuclide content of the IXMs have been established to assure that the dose rate from the in-service IXM is consistent with as low as reasonably achievable (ALARA) practices and the IXM does not exceed dose rate and radionuclide content limits contained in the Safety Analysis Report for Packaging (SARP) and Solid Waste Acceptance Criteria. These limits are based on the Cesium-137 and transuranic isotope inventory of the IXM. Cesium-137 is the principle gamma emitting radionuclide present and is used (by ratio) to determine the concentration of the other fission and activation products present in the PWC process streams. Total alpha (the sum of all alpha emitting radionuclides) content bounds the transuranic isotope content of an IXM. The administrative limit for Cs-137 inventory in the IXM is 300 Curies. The administrative limit for transuranic isotope inventory in an IXM is 80 nCi/gram (1.5 Curies). These correspond to SARP and Solid Waste Acceptance Criteria of 500 Curies and 100 nCi/gram (1.8 Curies) respectively. The CVDF IXM will be isolated and the spare IXM brought on line prior to reaching these administrative limits.

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APPENDIX A - CONVERSION FACTORS

The following conversion factors have been calculated using isotopic distribution data from HNF-SD-SNF-TI-09, Vol. 1, Rev. 2, *105-K Basin Material Design Basis Feed Description For Spent Nuclear Fuel Project Facilities, Volume 1, Fuel*, Table 3.5 "Radionuclide Inventory of the Combined K Basins." The data was derived using the ORIGIN 2 and RADNUC computer models. These factors are used to calculate the concentration of reportable radionuclides based on the ratio of fission and activation products to Cs-137 concentration and the ratio of actinides, transuranic isotopes and uranium to Total Alpha concentration.

Table A-1 Conversion Factors for Fission and Activation Products

Multiply	By	To Obtain
Cs-137	4.91E-05	C-14
	4.39E-04	Co-60
	6.02E-06	Se-79
	7.78E-01	Sr-90
	2.01E-04	Tc-99
	1.29E-03	Ru-106
	4.39E-07	I-129
	3.43E-03	Cs-134
	1.00E+00	Cs-137
	1.33E-03	Ce-144
	9.48E-03	Eu-154
	2.45E-03	Eu-155

Table A-2 Conversion Factors for Actinides, Transuranic Isotopes and Uranium

Multiply	By	To Obtain
Total Alpha	1.30E-03	U-234
	5.05E-05	U-235
	1.89E-04	U-236
	1.03E-03	U-238
	2.58E-03	U (Gross)
	9.71E-05	Np-237
	3.34E-01	Pu-239
	1.93E-01	Pu-240
	5.27E-01	Pu-239/240
	1.10E+01	Pu-241
	4.68E-01	Am-241
	2.24E-03	Cm-244

APPENDIX B - CVDF EFFLUENT RADIONCULIDE CONCENTRATIONS

The estimated radionuclide concentrations in the CVD Facility effluent stream were calculated using the follow assumptions:

1. The quantity of uranium oxide transferred from a design basis MCO is 75 grams, which equals 66 grams of uranium (SNF-5197).
2. 100% of soluble radionuclides will go into solution (SNF-5197).
3. The combined DF for multiple passes through Ion Exchange and Ion Exchange/Filtration is 10,000.
4. The average volume of water transferred from an MCO is 300 gallons.

Table B-2 CVD Facility Effluent Radionuclide Concentrations and ETF Acceptance Criteria

Isotope	Ci/MTU	Ci/gm	Ci/L (Treated)	ETF Acceptance Criteria Ci/L
Am-241	3.15E+05	2.08E+01	1.83E-06	1.40E-09
Sb-125	7.17E+04	4.73E+00	4.17E-07	Note 1
Ce-144	1.80E+04	1.19E+00	1.05E-07	8.30E-07
CS-134	4.63E+04	3.06E+00	2.69E-07	4.10E-07
Cs-137	1.35E+07	8.91E+02	7.85E-05	9.90E-06
Co-60	5.92E+03	3.91E-01	3.44E-08	2.40E-06
Cm-242	2.90E+02	1.91E-02	1.69E-09	Note 1
CM-244	1.51E+03	9.97E-02	8.78E-09	2.50E-08
Eu-152	1.02E+03	6.73E-02	5.93E-09	Note 1
Eu-154	1.28E-05	8.45E-10	7.44E-17	9.80E-06
Eu-155	3.31E+04	2.18E+00	1.92E-07	6.30E-05
Np-237	6.54E+01	4.32E-03	3.80E-10	2.10E-09
Nb-94	Note 2			2.60E-07
Pu-238	1.25E+05	8.25E+00	7.27E-07	2.80E-09
Pu-239/240	3.55E+05	2.34E+01	2.06E-06	1.70E-08
Ra-226	Note 2			6.40E-08
Ru-103	2.22E-15	1.47E-19	1.29E-26	Note 1
Ru-106	1.74E+04	1.15E+00	1.01E-07	6.50E-07
Se-79	8.31E+01	5.48E-03	4.83E-10	1.50E-07
Sr-90	1.05E+07	6.93E+02	6.10E-05	4.20E-05
Sn-113	3.63E+04	2.40E+00	2.11E-07	Note 1
Zn-65	Note 2			Note 1
C-14	6.63E+02	4.38E-02	3.85E-09	1.60E-06
I-129	5.93E+01	3.91E-04	3.45E-11	1.80E-06
Tc-99	2.72E+03	1.80E-01	1.58E-08	1.80E-05
Tritium	4.15E-04	2.74E-08	2.41E-15	2.40E-04

Note 1: Acceptance criteria for this isotope not listed in HNF-3172 Table, C-3
Note 2: Activity for this isotope not listed in WHC-SD-TI-009, Table 3.5