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Page 1 of 1

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7. Abstract A plan which provides a the methodology for the characterization of solid, low-level waste (LLW) and solid radioactive mixed waste (MW) generated at the PUREX Facility. This document only serves as an overview of the PUREX radionuclide characterization methodology and provides specific examples for how the radionuclide distribution is derived.		
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PUREX LOW-LEVEL WASTE RADIONUCLIDE CHARACTERIZATION

Prepared by

M. W. Ellis/G. J. LeBaron

PUREX Regulatory Compliance

WHC-SD-CP-PLN-028, Revision 0

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1.0 INTRODUCTION

The PUREX Low-level Waste (LLW) Radionuclide Characterization document describes the methodology for the characterization of solid low-level waste (LLW) and solid low-level mixed waste (MW) with the respect to radiological characteristics. This document only serves as an overview of the PUREX radionuclide characterization methodology and provides specific examples for how the radionuclide distribution is derived. It would be impractical to provide all background information in this document. If further clarification and background information is required, consult the PUREX Regulatory Compliance group files.

1.1 Scope

This document applies to only that waste generated in or is the responsibility of the PUREX facilities. The scope of this document is derived from the requirements found in the Department of Energy (DOE) Order 5820.2A, "Radioactive Waste Management", and the "Hanford Site Radioactive Solid Waste Acceptance Criteria," WHC-EP-0063 (current revision).

1.2 Facility Description

The PUREX facility is located in the 200 east area on the Hanford Site, approximately 20 miles north of Richland, Washington.

The facility was constructed in 1952 and designed to recover plutonium and uranium from spent nuclear fuel. This was accomplished by chemical dissolution of the fuel, and the use of solvent extraction to separate and recover plutonium and uranium. The PUREX facility became operational in 1956 and operated continuously until its shutdown in September 1972. The shutdown was caused by the closure of eight of the nine materials production reactors located at the Hanford site. The facility was in a "wet standby" condition from 1972 to 1978. In November 1983, it resumed operations to reprocess the inventory of stored N-Reactor fuel. Operations was terminated in December 1989 to readdress safety requirements. From February 1990 until March 1990 the facility operated to stabilize the facility for an extended shutdown period. In February 1991, PUREX facility operations were terminated by the Department of Energy and the facility is in standby in preparation of deactivation.

The PUREX complex consists of a main processing building (202-A) and miscellaneous surrounding support facilities.

- o 202-A building - consists of personnel offices, chemical preparation (AMU), laboratory, process control rooms, service areas, galleries, process cells and related equipment, etc..
- o Support facilities - include personnel offices, storage tanks, air emission stacks, egress, storage, sampling shacks, filter buildings, etc..

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The above areas can be divided into zones of low, moderate, and high risk of employee exposure to radiation or radioactive contamination. Activities conducted in the moderate and high risk areas are generating points for LLW. Hazardous material/waste activities in the moderate and high risk areas are generating points for MW.

2.0 RADIOACTIVE WASTE CHARACTERIZATION REQUIREMENTS

The U.S. Department of Energy (DOE) establishes the requirements for radioactive solid waste in DOE Order 5820.2A Radioactive Waste Management. Chapters II and III from DOE Order 5820.2A requires that generators of solid wastes in the LLW categories and the radioactive mixed waste subcategories: (1) identify the major radionuclides in each solid waste matrix, and (2) determine the radionuclide concentrations and waste classes of their solid wastes. In addition, the Order also requires each generator to carry out a compliance program that ensures the proper certification of the solid waste generated.

The Westinghouse Hanford Company WHC-EP-0063 manual (current revision) Hanford Site Solid Waste Acceptance Criteria implements DOE Order 5820.2A. The manual states that the disposal category and the reportable radionuclides must be reported as follows;

- o Report all radionuclides with a half-life less than 5 years if process knowledge or analysis indicates they exist at greater than one percent of the total curie amount in the waste,
- o Report only those radionuclides of the Table 1 that process knowledge indicates are present in the waste if they exist at greater than 1/100 (1%) of the Table 1 category 1 limit. Activities less than minimum detectable analysis limits but greater than the 1/100 (1%) Table 1 category 1 limit, should be reported based on scaling factors or process knowledge,
- o Daughter products in secular equilibrium with the parent radionuclide do not need to be reported (report only the Ci value of the parent radionuclide),
- o Cases may occur where no radionuclides are detected but the waste material cannot be released for nonradioactive disposal. In such cases, report only those radionuclides on Table 1 and only those that would most likely be present based on process knowledge. Use the detection limit of the survey instrument involved and process knowledge to determine the reportable curie values, and
- o Classify all LLW according to Category 1, 3, and greater than Category 3 concentration limits. All waste of different categories must be segregated prior to shipment to the burial grounds.

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The characterization of PUREX LLW also requires consideration of the following factors;

- a. The radiation level at the surface of the waste container, (i.e., contact handled at <200 mrem/h versus remote handled at ≥ 200 mrem/h), and
- b. Whether the waste material includes hazardous constituents as defined by RCRA, TSCA, or the WAC.

Note - this plan only addresses the radionuclide characterization, hazardous constituents and segregation are addressed in the "PUREX Solid, Low-level Waste Certification Plan", WHC-SD-CP-PLN-009.

Table 1. WHC-EP-0063-4 Radionuclide Table

Nuclide	Activity Limits (Ci/m ³)	
	Category 1	Category 3
³ H	5.0 E+06	**
¹⁰ Be	1.0 E+00	2.2 E+02
¹⁴ C	4.0 E-02	9.1 E+00
¹⁴ C*	4.0 E-01	9.1 E+01
³⁶ Cl	4.0 E-04	8.3 E-02
⁴⁰ K	1.7 E-03	3.4 E-01
⁶⁰ Co	7.7 E+01	
⁵⁵ Ni	4.0 E+00	8.3 E+02
⁵⁵ Ni*	4.0 E+01	8.3 E+03
⁶³ Ni	4.8 E+00	1.7 E+04
⁶³ Ni*	4.8 E+01	1.7 E+05
⁷⁶ Se	3.8 E-01	8.3 E+01
⁸⁰ Sr	4.3 E-03	1.5 E+04
⁸³ Zr	2.7 E+00	5.9 E+02
⁸⁴ Nb	2.6 E-04	5.6 E-02
⁸⁴ Nb*	2.6 E-03	5.6 E-01
⁸³ Mo	3.0 E-01	7.1 E+01
⁹⁹ Tc	5.5 E-03	1.2 E+00
⁹⁹ Tc	5.6 E-03	1.2 E+00
¹⁰⁷ Pd	4.8 E+00	1.0 E+03
^{113m} Cd	2.0 E-01	
^{121m} Sn	6.3 E+00	2.0 E+05
¹²⁶ Sn	1.8 E-04	
¹²⁹ I	2.9 E-03	5.9 E-01

Nuclide	Activity Limit (Ci/m ³)	
	Category 1	Category 3
¹³⁵ Ba	7.7 E-01	
¹³⁶ Cs	1.9 E-01	4.2 E+01
¹³⁷ Cs	6.3 E-03	1.3 E+04
¹⁴⁷ Sm	1.6 E-02	3.4 E+00
¹⁵¹ Sm	3.8 E+01	1.8 E+05
¹⁶⁰ Eu	1.6 E-03	7.7 E+02
¹⁶² Eu	5.3E-02	
¹⁶⁴ Eu	8.3E-01	
¹⁵² Gd	6.3 E-03	1.3 E+00
¹⁸⁷ Re	5.3 E+00	1.1 E+03
²⁰⁹ Po	2.9 E-02	7.7 E+01
²¹⁰ Pb	1.0 E-02	5.6 E+05
²²⁶ Ra	1.4 E-04	3.6 E-02
²²⁸ Ra	1.9 E+01	
²²⁷ Ac	4.5 E-03	3.2 E+05
²²⁹ Th	4.8 E-04	1.1 E-01
²³⁰ Th	2.1 E-03	1.3 E-01
²³² Th	1.2 E-04	2.2 E-02
²³¹ Pa	1.6 E-04	3.3 E-02
²³² U	5.3 E-04	4.0 E+00
²³³ U*	7.7 E-03	1.1 E+00
²³⁴ U	9.1 E-03	2.1 E+00
²³⁵ U	3.2 E-03	5.9 E-01
²³⁶ U	1.0 E-02	2.2 E+00
²³⁸ U	6.3 E-03	1.4 E+00

Nuclide	Activity Limits (Ci/m ³)	
	Category 1	Category 3
²³⁷ Np*	1.9 E-04	4.0 E-02
²³⁸ Pu*	9.1 E-03	4.5 E+01
²³⁹ Pu*	3.6 E-03	7.7 E-01
²⁴⁰ Pu*	3.6 E-03	7.7 E-01
²⁴¹ Pu*	7.7 E-02	3.1 E+01
²⁴² Pu*	3.8 E-03	8.3 E-01
²⁴⁴ Pu*	8.3 E-04	1.7 E-01
²⁴¹ Am*	2.6 E-03	1.1 E+00
^{242m} Am*	2.6 E-03	2.4 E+00
²⁴³ Am*	1.3 E-03	2.8 E-01
²⁴³ Cm*	2.5 E-02	6.3 E+02
²⁴⁴ Cm*	2.3 E-01	2.9 E+02
²⁴⁶ Cm*	2.1 E-03	3.3 E-01
²⁴⁶ Cm*	3.3 E-03	7.7 E-01
²⁴⁷ Cm*	7.1 E-04	1.5 E-01
²⁴⁸ Cm*	9.1 E-04	2.0 E-01

* Limit for isotope in activated metal.

* Category 3 limit is the lower of this value and 100 nCi/g.

** A blank indicates that no upper limit exists for this isotope

3.0 METHODOLOGY FOR DETERMINING RADIONUCLIDE AND ACTIVITIES

The PUREX Facility methodology used to determine radionuclide, distribution, and specific activities for LLW and MW is two fold, 1) using SD-CP-TI-077 (3/12/85), "ORIGEN II Predictions of N-Reactor Fuel Fission Product Composition" to find the radionuclide and their relative distribution which contribute 1% or more to the total curies for each fuel age tabulated, and 2) using technical smear sampling to determine the relative activities of the waste generated within various radioactive areas.

3.1 ORIGEN II PREDICTIONS FOR N-REACTOR FUEL

The tables of decay characteristics of N-Reactor fuel are given for a range of fuel exposures and decay times (see FIGURE 1 for example page; to review complete document contact PUREX Regulatory Compliance). It has been determined the decay characteristics of 7.5 year old fuel is the most representative of the waste presently generated due to the fact that PUREX has not operated since 1988 and the fuel processed at that time was approximately two years old.

Using the 7.5 year old decay characteristics, the total curies produced by the fuel was calculated. Each radionuclide listed was evaluated with regards to their specific curies contribution to the calculated totals respectively. If the distribution for each was greater to or equal to 1%, the radionuclide was recorded and considered to be part of the LLW and MW generated. The following assumptions have been made in order to proceed with the radionuclide characterization;

- o The proportional relationship between radionuclides in PUREX waste streams remain relatively constant with what is theoretically predicted to be in the fuel using "ORIGEN II",
- o the isotopes of Hydrogen, Krypton, and Xenon were released as gases during fuel dissolution,
- o sixty-five percent of the Iodine 129 was captured in the dissolver off-gas system by removal with silver nitrate,
- o because PUREX has not operated since 1988, no additional radioactive material has been generated,
- o the only change in the radioactive concentrations of the waste streams has been due to radioactive decay,
- o a substantial amount of the short lived radionuclides (half-lives less than 135 days) have decayed to a level considered to be insignificant for purposes of waste disposal and characterization, and

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DECAY OF MX IV ASSEMBLY OF N REACTOR FUEL 6 X PU 240 SD-CP-TI-077
POWER= 1.00000+000 MW, BURNUP= 1.00000+000 MWD, FLUX= 1.00+000 N/CM**2-SEC

FISSION PRODUCTS

7 SUMMARY TABLE: RADIOACTIVITY, Curies												
ONE METRIC TON OF MX IV 6X 240 PU FUEL												
DISCHARGE	120.0D	180.0D	.8YR	1.0YR	1.5YR	2.0YR	3.0YR	4.0YR	5.0YR	7.5YR	10.0YR	
MO102	4.400+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC102	4.403+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC102M	3.282+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
SR103	1.241+000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Y103	8.185+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR103	5.839+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB103	2.423+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO107	3.727+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC107	3.770+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RU103	2.697+005	3.246+004	1.126+004	2.146+003	4.285+002	1.708+001	6.807+001	1.081+003	1.717+005	2.728+009	2.744+016	2.780+023
RH103M	2.430+005	2.926+004	1.015+004	1.935+003	3.863+002	1.540+001	6.137+001	9.748+004	1.548+006	2.459+009	2.473+016	2.488+023
SR104	4.525+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Y104	6.124+001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR104	1.147+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB104	1.016+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO104	2.576+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC104	2.722+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH104	1.488+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH104M	1.077+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Y105	3.466+000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR105	1.508+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB105	3.069+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO105	1.611+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC105	1.935+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RU105	1.952+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH105	1.737+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH105M	5.466+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR106	2.274+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB106	8.358+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO106	7.282+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC106	1.116+005	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RU106	1.594+004	1.272+004	1.136+004	9.518+003	8.014+003	5.883+003	4.029+003	2.026+003	1.018+003	5.120+002	9.177+001	1.645+001
RH106	3.070+004	1.272+004	1.136+004	9.518+003	8.014+003	5.883+003	4.029+003	2.026+003	1.018+003	5.120+002	9.177+001	1.645+001
RH106M	7.171+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR107	1.097+001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB107	1.236+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO107	2.353+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC107	5.267+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH107	8.282+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH107	8.277+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
PD107	1.681+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003	1.682+003
PD107M	5.945+001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ZR108	3.048+000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB108	3.822+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MO108	9.207+003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TC108	3.138+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RU108	5.325+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH108	5.375+004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
RH108M	5.000+002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
AG108	1.723+002	2.829+003	2.826+003	2.822+003	2.818+003	2.811+003	2.803+003	2.788+003	2.773+003	2.758+003	2.720+003	2.683+003
ZR109	2.183+001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
NB109	7.299+001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Figure 1. ORIGEN II Radionuclide Decay Characteristic Example

- o the LLW and MW generated comes into contact with the fuel processed indirectly through processes such as process stream samples, maintenance and operating activities, decontamination efforts, etc..

The following list was prepared from the ORIGEN II tables for 7.5 year old fuel. The radionuclide listed by curies are only those which contribute 1% of more to the total curies. The isotopes ^3H and ^{14}C are two additional radionuclides which, although they do not contribute 1% or more in curies or mass, are required to be reported per "Guidance Document for Implementation of DOE Order 5820.2A Chapter III: Management of Low-level Radioactive Waste," DOE/LLW-38T.

RADIONUCLIDE	CURIES (6% Pu240 - ONE METRIC TON)	CURIE %
^3H	1.158E+01	8.000E-02
^{14}C	3.926E-06	2.750E-08
** ^{85}Kr	2.442E+02	1.710E+00
^{90}Sr	2.539E+03	1.776E+01
^{90}Y	2.540E+03	1.776E+01
^{137}Cs	2.957E+03	2.069E+01
$^{137}\text{Ba}_m$	2.797E+03	1.957E+01
^{147}Pm	1.833E+03	1.283E+01
^{241}Pu	5.890E+02	4.120E+00

** - Krypton was released as a gas during fuel dissolution and is not reported on waste disposal documentation.

3.2 TECHNICAL SMEAR SAMPLING

The actual levels of activity of specific radionuclide are determined by obtaining various technical smear samples of specific areas (Table 2 and Figures 2-3) and having analyses of each completed.

It was concluded that this particular approach for characterization was appropriate due to the following;

1. The areas chosen for sampling are the primary areas within PUREX in which the majority of the LLW is generated.
2. The PUREX facility is not currently operating and no additional radioactive material has been generated.

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3. The only change in the radionuclide concentrations of the waste streams has been due to radioactive decay, and any additional processing operations or maintenance activities that might have transferred radionuclides from one stream to another. For example, the concentration of radionuclides at the west or east crane maintenance platform may have increased when process equipment is transferred to the PUREX storage tunnel.
4. The waste generated results from direct incidental contact with the areas contaminated with radionuclide resulting from the processing of N-Reactor fuel.
5. The substantial amount of the short lived radionuclide (half-lives less than 135 days) have decayed to a level considered to be insignificant for purposes of waste disposal and characterization.

Table 2. Smear Sample Locations

1.	203-A UNH Pump House
2.	Railroad Cut
3.	206-A Fractionator
4.	295-AB Process Distillate Discharge
5.	295-AC Steam Condensate Discharge
6.	293-A Disolver Off-gas
7.	292-AB Main Stack
8.	291-AE #4 Filter Building
9.	East Crane Maintenance Platform
10.	West Crane Maintenance Platform
11.	White Room
12.	Canyon Lobby
13.	East Sample Gallery
14.	Sample Gallery Sample Station
15.	Entrance Door to U-Cell
16.	West Sample Gallery
17.	Hotshop
18.	Mezzanine Stairs in Pipe and Operating Gallery
19.	Storage Gallery
20.	Plutonium Reclamation Corridor outside R-Cell
21.	Plutonium Reclamation Room
22.	N-Cell Loadout Room
23.	Upper and Lower Glove Box Room
24.	Entrance to Q-Cell Control Room
25.	Laboratory Hot Waste Storage Room
26.	Room 50 Lab 1
27.	Room 51 Lab 2
28.	Room 52 Decon Lab
29.	Room 53 Lab 3
30.	Room 55 Counting Room
31.	Room 58 Lab 4
32.	Room 60 Lab 5
33.	Room 66 Lab 6

Figure 2. Smear Sample Locations cont.

Figure 3. Smear Sample Locations cont.

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Four initial samples of each generation area has been taken to set an initial basis for the radionuclides and their specific activities. Sampling is an annual activity unless the plant configuration changes; at the time the configuration change a sampling campaign will be implemented. Also, because radiation zone reduction is a part of the deactivation activities at PUREX, when an area presently sampled for radioactive characterization is zone reduced or deactivated, characterization sampling will be terminated.

Sampling in these areas using technical smears is completed using administrative procedure WHC-CM-5-9, 4.27, "Radionuclide Characterization For PUREX LLW Solid Wastes," and "HPT Scheduled Radiation Survey Task Description," #A-90.

The smear sampling is completed by the PUREX Health Physics organization as requested by PUREX Regulatory Compliance. The initial samples were taken at approximately one month intervals for four months. The samples were taken by a different Health Physics Technicians (HPT) for each interval of sampling (to assure the areas were randomly sampled). The HPT obtained a gross smear sample of each area outlined in Section 3.1.1 using a 47mm diameter Mohawk Swipe. The number of smear points or the size of the area to be smeared are representative of the area sampled (i.e., a large area will have more smears point relative to a small room, etc.). The initial samples serve the purpose of a basis to initially characterize LLW and MW. Further samples will be taken on an annual bases or when the facility configuration changes (i.e., process new fuel).

3.2.1 222-S ANALYTICAL LABORATORY

Once the PUREX Health Physics organization obtains the smear samples, the samples are shipped to the 222-S Laboratory per the appropriate routine Radioactive Shipment Record. The analyses preformed by the laboratory are varied based on the capabilities of the lab. There are specific radionuclide (i.e., ^{129}I , ^{99}Tc , etc.) which 222-S cannot quantify in solids because they require the development of specific chemical separation procedures, etc., which are not currently available at the 222-S laboratory.

For known nuclides in PUREX LLW (based on ORIGEN II), and where lab analyses are available for those nuclide, PUREX Regulatory Compliance requests analyses. Because the current limitation of the lab, the nuclide ^{90}Sr is used to correlate the relative radioactive activities within PUREX LLW and MW (refer to Section 3.3). The remainder of the nuclides listed on the lab results are considered for background information only.

PUREX Regulatory Compliance is currently pursuing an offsite laboratory for further characterization. The future goal is to fully characterize PUREX LLW using laboratory analyses.

3.3 LABORATORY RESULTS

Figure 4 provides an example of a 222-S analyses results. The results are identified according to the area sampled, PUREX sample number, 222-S sample number, and date of analyses. Because the results for the general areas (i.e., sample gallery, outside radiation zones, etc.) throughout the PUREX complex, excluding the crane maintenance platforms (CMP) and the 203A tank farm, are within the same order of magnitude with respect to ^{90}Sr , the areas were combined as one stream (respective to rad characteristics only). The dose rate for the CMP wastes determines as to whether or not the it is disposed of in the general waste stream. For CMP wastes with a dose rate of ≤ 1 mRad/hr, the waste is not segregated from the general waste stream because calculations have determined that this waste is the same waste category (i.e., category 1) as the general waste stream. The CMP wastes with a dose rate of greater than 1 mRad/hr is segregated from the general waste stream because the higher activities of the CMP waste potentially constitutes a higher waste category. The 203-A tank farm wastes are segregated from the general waste forms because the area contains uranyl nitrate hexahydrate (UNH), which consists primarily of U isotopes (based on process knowledge of UNH, Figure 5).

The laboratory results of the ^{90}Sr activities for the three different streams are averaged and the results are used to correlate the curie percentage for the remaining nuclide identified from ORIGEN II (see Figure 6 for example nuclide activity calculations). The ^{90}Sr results are used for correlating the curie percent of each nuclide in the streams because the laboratory method for obtaining the ^{90}Sr activity is relatively accurate.

The average dose rate for the samples taken is less than 0.5 mRad/hr and the average weight for the samples is 0.3 grams.

DATE OF ANALYSIS					
PUREX SAMPLE NUMBER/AREA SAMPLED					
222-S SAMPLE NUMBER					
SAMPLE STATUS REPORT FOR E 6144. PUREX #29					
DISPATCHED: 6/20/91 11:38 SAMPLE HAS BEEN SLURPED					
RECEIVED: 6/20/91 13:21					
TIME: 9/10/91 15:47					
EXT.	DETER.	RESULTS OR STATUS	OUT OF RANGE	GOOD ANS?	CHARGE CODE
****	*****	*****	***	***	*****
1234	TB-FLTER	5.72000E-06 uCi/Sample	N	Y	KP32A
1293	AT-FLTER	< 9.99999E-07 uCi/Sample	N	Y	KP32A
2154	GEA-FLTR	< 1.73000E 01 pCi/Sample Cs-137	N	Y	KP32A

Figure 4. 222-S Laboratory Sample Results Example

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Specific activity (uCi/gram) for Uranium Mixture in UNH

Uranium Isotope Weight Percent from Uranyl Nitrate Hexahydrate Analyses
(See Attached Sample Status Reports)

Isotope	Weight Percent		Average Wt %
	Tank P-3	Tank P-4	
U-234	0.009	0.009	0.009
U-235	0.947	0.893	0.92
U-236	0.07	0.072	0.071
U-238	98.974	99.026	99
	100	100	100

Specific Activity of Uranium Mixture in Uranyl Nitrate Hexahydrate

Isotope	Isotopic Specific Activity (Ci/g)	Wt %	Isotopic Specific Activity (uCi/g) in UNH
U-234	6.253E-03	0.009	5.622E-01
U-235	2.163E-06	0.92	1.990E-02
U-236	6.474E-05	0.071	4.597E-02
U-238	3.364E-07	99	3.330E-01

Specific Activity of Uranium Mixture= 0.962

Figure 5. Uranyl Nitrate Hexahydrate Process Knowledge

Nuclide	Activity (Ci) (ORIGEN II*)	Correlation Factor relative to ^{90}Sr
^3H	1.580E+01	$1.580\text{E}+01/2.539\text{E}+03 = 6.223\text{E}-03$
^{14}C	3.926E-06	$3.926\text{E}-06/2.539\text{E}+03 = 1.546\text{E}-19$
^{90}Sr	2.539E+03	$2.539\text{E}+03/2.539\text{E}+03 = 1.000\text{E}+00$
^{90}Y	2.540E+03	$2.540\text{E}+03/2.539\text{E}+03 = 1.000\text{E}+00$
^{137}Cs	2.957E+03	$2.957\text{E}+03/2.539\text{E}+03 = 1.165\text{E}+00$
$^{137}\text{Ba}_m$	2.797E+03	$2.797\text{E}+03/2.539\text{E}+03 = 1.102\text{E}+00$
^{147}Pm	1.833E+03	$1.833\text{E}+03/2.539\text{E}+03 = 7.219\text{E}-01$
^{241}Pu	5.890E+02	$5.890\text{E}+02/2.539\text{E}+03 = 2.320\text{E}-01$

* - Activities are base on one metric ton of MK IV 6% ^{240}Pu fuel and fuel age of 7.5 years after discharge per ORIGEN II.

Nuclide	Nuclide Activity (Ci/sample) (correlation factor * ^{90}Sr activity per sample results)
^3H	$6.223\text{E}-03 * 3.70\text{E}-11 \text{ ci/sample} = 2.30\text{E}-13$
^{14}C	$1.546\text{E}-19 * 3.70\text{E}-11 \text{ ci/sample} = 5.74\text{E}-20$
^{90}Sr	$1.000\text{E}+00 * 3.70\text{E}-11 \text{ ci/sample} = 3.70\text{E}-11$
^{90}Y	$1.000\text{E}+00 * 3.70\text{E}-11 \text{ ci/sample} = 3.70\text{E}-11$
^{137}Cs	$1.165\text{E}+00 * 3.70\text{E}-11 \text{ ci/sample} = 4.29\text{E}-11$
$^{137}\text{Ba}_m$	$1.102\text{E}+00 * 3.70\text{E}-11 \text{ ci/sample} = 4.07\text{E}-11$
^{147}Pm	$7.219\text{E}-01 * 3.70\text{E}-11 \text{ ci/sample} = 2.67\text{E}-11$
^{241}Pu	$2.320\text{E}-01 * 3.70\text{E}-11 \text{ ci/sample} = 8.58\text{E}-12$

Nuclide	Nuclide Activity (Ci/gram waste) (correlation factor * ^{90}Sr activity per sample results)
^3H	$2.30\text{E}-13 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 7.67\text{E}-13$
^{14}C	$5.74\text{E}-20 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 1.91\text{E}-19$
^{90}Sr	$3.70\text{E}-11 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 1.23\text{E}-10$
^{90}Y	$3.70\text{E}-11 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 1.23\text{E}-10$
^{137}Cs	$4.29\text{E}-11 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 1.43\text{E}-10$
$^{137}\text{Ba}_m$	$4.07\text{E}-11 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 1.36\text{E}-10$
^{147}Pm	$2.67\text{E}-11 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 8.90\text{E}-11$
^{241}Pu	$8.58\text{E}-12 \text{ ci/sample} * 1 \text{ sample}/0.3 \text{ gram} = 2.86\text{E}-11$

Figure 6. PUREX Radionuclide Activity Calculations

4.0 SHIPPING PAPER CALCULATIONS AND REPORTING

Documentation for shipping LLW and MW to the central waste complex considers the radionuclide as determined by ORIGEN II, their relative radioactive activities as determined by smear sampling, as well as the dose rate and the net weight from the container(s). The radionuclide activities from the smear sampling are relative to a sample dose rate of 0.5 mRad/hr, the radionuclide activities for the waste being shipped must be corrected for actual package dose rates. Also, because the final radionuclide activity on the shipping paper is required to be reported in curies and the activities from the correlated values is curies per gram, the reported radionuclide distribution requires a correction for the actual net weight of the waste (see Figure 7 for shipping paper calculations).

It is assumed that because the majority of the waste shipped from PUREX is paper, plastic, and rubber, the density of the sample material (paper) is representative of the waste. When a package has a matrix which is more dense (i.e., metal, wood, concrete, etc.) than that of the smear samples, the radionuclide activities reported are considered conservative (high) with respect to the actual waste activity. As long as the conservative approach allows the waste to be shipped as Category 1 waste, as defined by WHC-EP-00063 current revision, and within a manageable shipping category (i.e., limited quantity, low specific activity, type A) the conservative approach is followed. Currently, there has not been a container shipped from PUREX using this method that is over the Category 1 limit or of a unmanageable transportation category. This is primarily due to the low dose rate of the waste generated and containers are limited for their gross weights.

5.0 CONCLUSION

Table 4 provides a summary of the three radionuclide distributions for LLW and MW shipped from PUREX. For detailed calculations, further sample results for the areas sampled, and additional background information regarding the PUREX radionuclide distribution, consult the PUREX Regulatory Compliance group radionuclide distribution file.

AREA: GENERAL (sample gallery, misc. zones, etc..)

CONTAINER PIN: _____

GRAMS OF WASTE: _____

DOSE RATE @ CONTACT: _____

Nuclide	Activity (Ci/g)	grams waste/container	Ci/container
^3H	7.67E-13		
^{14}C	1.91E-19		
$^{90}\text{Sr}/^{90}\text{Y}$	1.23E-10		
$^{137}\text{Cs}/^{137}\text{Ba}_m$	1.43E-10		
^{147}Pm	8.90E-11		
^{241}Pu	2.86E-11		
Total fission/activation Ci: _____			
Total grams Pu/container _____ *		Ttl Ci _____ (including ^{241}Pu)	

* Total grams Pu/container = (Ci ^{241}Pu /container * 9.71E-03 g/Ci ^{241}Pu)

NOTE: Only complete this section if the waste has a dose rate at contact greater than 0.5 mRad/hr.

The total curies for the container must be adjusted for waste which has a dose rate greater than 0.5 mRad/hr (based on sample dose rate average of 0.5 mRad/hr).

Nuclide	Ci/container (old) (from above table)	Dose Rate @ Contact	Dose rate /0.5	Ci/container (new) **
^3H				
^{14}C				
$^{90}\text{Sr}/^{90}\text{Y}$				
$^{137}\text{Cs}/^{137}\text{Ba}_m$				
^{147}Pm				
^{241}Pu				
Total fission/activation Ci: _____				
Ttl Grams: _____ (Pu/container)		Ttl Ci: _____ (including ^{241}Pu)		

** Ci/container (new) = Ci/container (old) * Dose Rate at Contact/0.5

Figure 7. Shipping Paper Calculations

Table 3. PUREX Radionuclide Distributions

AREA: General (sample gallery, misc rad zones, etc.)	
NUCLIDE	ACTIVITY (Ci/g waste)
^{14}C	1.90e-19
^3H	5.62E-13
$^{90}\text{Sr}/^{90}\text{Y}$	1.23E-10
$^{137}\text{Cs}/^{137\text{m}}\text{Ba}$	1.43E-10
^{147}Pm	8.90E-11
^{241}Pu	2.86E-11

AREA: Crane Maintenance Platforms / Hotshop	
NUCLIDE	ACTIVITY (Ci/g waste)
^{14}C	1.96e-16
^3H	5.75E-10
$^{90}\text{Sr}/^{90}\text{Y}$	1.26E-07
$^{137}\text{Cs}/^{137\text{m}}\text{Ba}$	1.46E-07
^{147}Pm	9.11E-08
^{241}Pu	2.93E-08

AREA: 203-A Tank Farms	
NUCLIDE	ACTIVITY (Ci/g waste)
$^{90}\text{Sr}/^{90}\text{Y}$	1.56E-17
^{99}Tc	5.64E-10
^{235}U	6.62E-12
^{238}U	1.12E-10